COSTS OF STORING RESERVE STOCKS OF CORN

in Country Elevators, at Bin Sites, and on Farms

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CONTENTS

COSTS OF STORING RESERVE STOCKS OF CORN IN COUNTRY ELEVATORS, AT BIN SITES, AND ON FARMS

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SUMMARY

The inadequacy of storage space near production areas for grain carried over from the initial marketing season has created ever-growing problems in recent years. In planning construction of new facilities and additions to existing structures, costs associated with the storing of inter-seasonal stocks of grain are of primary importance to the grain trade, producers of grain, and governmental agencies. All of these groups have responsibilities for management of grain reserves. This report covers the findings of a study, made in Iowa during 1952 and 1953, of costs of storing reserves of corn at country elevators, at bin sites,[1] and on farms. A similar study for wheat was made in Kansas during the same period.

The costs of storage in country elevators are based on accounting records of a sample of elevators selected to represent the principal types of construction, types of organization, and types of farming areas in the State. The storage capacity of elevators studied varied from 40,000 to 800,000 bushels, and all had some storage space constructed since 1946.

Accounting records on all of the bins in a sample of 10 Iowa counties formed the basis for determining storage costs at bin sites. The counties were located throughout the State, and the study covered bin sites in grain deficit areas as well as surplus grain-producing areas. Storage facilities at bin sites included round metal bins, prefabricated steel structures, and wooden storage facilities. Capacity varied from about 300,000 to over 4,000,000 bushels per county.

Farm storage costs, on the other hand, are based on budgeted costs, using engineering specifications for structures, rather than on accounting records. Costs of materials, construction, and maintenance were computed for three types of farm storage structures--the conventional double wooden corncrib, a prefabricated steel building with mechanical ventilation for ear corn storage, and the round steel bin used for shelled corn. The size of the farm storage units ranged from 1,000 to 5,450 bushels.

The objective of this study was to measure and compare the costs of storing corn in alternative locations and types of structures. The problem was one of measuring storage costs in existing plants rather than one of minimizing costs or maximizing storage income within the plants. The data collected included information on volume and costs but not on profits or margins. Consequently, the study provides no basis for a comparison of the marginal productivity of resources allocated to the storage operation or to other departments within the elevator plants studied. It was not designed to do so. Total and average storage costs are assumed to be continuous functions of plant volume which are not constant over the entire volume range. Therefore, this study was directed toward the description of the shape as well as the level of cost curves associated with the storage function.

As was expected, most of the variation in storage cost was found to be associated with variation in the quantity of grain stored, the size and the degree of utilization of storage capacity, and the average length of storage.[1] As shown in table 1, the elevator

[1] See Definitions, p. 59.

TABLE 1.—Annual cost per bushel of interseasonal storage of corn at country elevators and in bin sites of selected capacities at three levels of capacity utilization

Type of storage	Average length of storage[1]	Costs of storage at 3 degrees of capacity utilization at elevators and bin sites with capacities of --														
		100,000 bushels			200,000 bushels			400,000 bushels[2]			800,000 bushels			1,500,000 bushels		
		80 pct.	90 pct.	100 pct.	80 pct.	90 pct.	100 pct.	80 pct.	90 pct.	100 pct.	80 pct.	90 pct.	100 pct.	80 pct.	90 pct.	100 pct.
	Years	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Elevator............	1	14.07	13.05	12.22	13.18	12.18	11.37	12.41	11.42	10.63	--	--	--	--	--	--
Bin site............		--	--	--	--	--	--	16.10	15.67	15.32	15.32	14.92	14.58	14.71	14.32	13.99
Elevator............	2	11.25	10.23	9.40	10.36	9.36	8.54	9.59	8.60	7.81	--	--	--	--	--	--
Bin site............		--	--	--	--	--	--	11.30	10.87	10.52	10.52	10.12	9.78	9.91	9.51	9.19
Elevator............	3	10.31	9.29	8.46	9.42	8.42	7.61	8.65	7.66	6.86	--	--	--	--	--	--
Bin site............		--	--	--	--	--	--	9.71	9.27	8.92	8.92	8.52	8.18	8.31	7.91	7.59
Elevator............	4	9.84	8.82	7.99	8.95	7.95	7.14	8.18	7.19	6.39	--	--	--	--	--	--
Bin site............		--	--	--	--	--	--	8.90	8.47	8.12	8.12	7.72	7.38	7.51	7.11	6.79
Elevator............	5	9.56	8.54	7.71	8.67	7.67	6.85	7.89	6.91	6.11	--	--	--	--	--	--
Bin site............		--	--	--	--	--	--	8.42	7.99	7.64	7.64	7.23	6.90	7.03	6.63	6.31

1 See Definitions, p. 59.
2 Since the average storage capacity of bin sites is much larger than that of individual country elevators, the only level at which comparison is made by volume is at the 400,000-bushel capacity.

storage costs decrease more rapidly with increasing volume than do bin site storage costs. Elevator and bin site storage costs also both decrease as storage turnover decreases, that is, as the average storage period increases. Other things being equal, annual bin site storage costs at full utilization of county capacity of 800,000 bushels would be reduced from 14.58 to 8.18 cents a bushel by rotating storage stocks every 3 years rather than every year. The reduction of storage costs by increasing the average length of storage is more pronounced in bin site storage than in elevator storage. This is due primarily to the higher costs of placing corn in the bins and removing it from them. This tends toward a cost advantage of storing at bin sites, given long average storage periods.

For shorter storage periods, annual costs are lower in elevators. Both bin site and elevator storage costs decrease as the degree of capacity utilization increases. This relationship can be seen in table 1 by comparing the 3 cost figures on any line for any capacity. These figures and the others in table 1 indicate that unused capacity tends to be more expensive in elevators than at bin sites.

This survey did not include a study of the actual costs of storing reserve stocks of corn on the farm. However, on the basis of budgeted costs, it appears reasonable to assume that, beyond the first year, farm storage costs would be higher than those for storing corn at bin sites or elevators, provided all cash and non-cash cost items were charged to farm storage and the same turnover of grain took place in the farm storage operations.

Although the storage of reserve stocks of corn on the farm may not be economical beyond the first year if cash and non-cash costs are taken into consideration, good farm management practices may justify such storage. This is especially true where farm storage facilities are available and there is no better alternative for using the surplus labor supply available to the farm operator.

INTRODUCTION

Objectives and Scope of Study

The rapid accumulation of grain stocks in recent years has accentuated the problem of finding adequate storage space for reserves carried for increasing periods of time beyond the initial marketing year. Studies were initiated during 1952 to assemble information on costs involved when various sizes and types of facilities are utilized for grain storage, irrespective of their ownership. The study was designed to provide information which could serve as a basis for more effective planning and operation of governmental grain storage programs. However, the data developed also may assist the grain trade and producers of grain in the solution of managerial problems in the storage of reserves of grain. Therefore, this report has been prepared for general distribution.[2]

Three storage locations were selected for analysis--on the farm, at country elevators, and in semipermanent steel and wood structures erected under recent conditions at bin sites in production areas. The records and actual operations of a sample of both country elevators and bin sites were studied. The cost of storing corn in farm facilities was estimated by budgeting based on engineering specifications and the costs of materials and labor for construction, maintenance and operation. Storage cost and volume figures were obtained for the last complete accounting year for each elevator included in the study. Although this was most frequently the calendar year 1951, many of the elevators used fiscal years other than the calendar year. The last month of the accounting year varied from September 1951 to September 1952. Corresponding figures for bin site storage were obtained for the period July 1951 through June 1952. Farm storage costs were based on estimates of constructing and equipping farm bins in Iowa during the fall of 1952.

Fixed and variable costs were computed for most of the elevators and bin sites, on the basis of actual expenditures, but imputed costs were developed where required for comparability. Both high and low cost units were included in the sample. Since the purpose of the investigation was to provide a basis for adding new space, antiquated structures without adequate physical facilities for handling stored grain were excluded.

Several factors which ordinarily may be considered as storage costs have not been included. No allowance was made for the costs of artificial drying of the corn. As this study is directed toward storage for periods longer than a single marketing year, it is assumed that drying would have already occurred during the first season, either through natural processes or by mechanical methods. Also, the costs of long-term storage that arise from deterioration of the quality and shrinkage of the stored grain over time were not included.[3] However, costs of aeration, fumigation, and other conditioning practices in the units studied, were included.

The volume ranges for the three storage locations studied for the most part are mutually exclusive, so that direct comparison is difficult. The capacity of bins on the county basis in Iowa was substantially greater than either the country elevator or farm storage units. The capacity of bins per county ranged from approximately 275 thousand to slightly more than 4 million bushels with an average capacity of 1.9 million bushels. Country elevators had licensed storage space from 40 thousand to 850 thousand bushels,

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[2] The Iowa Agricultural Experiment Station, Ames, Iowa, conducted the research on which this report is based, under contract with the U.S. Department of Agriculture, during the year July 1952 through June 1953, using funds made available under the Agricultural Marketing Act of 1946 (RMA - Title II). A study on cost of storing wheat in Kansas at elevators and bin sites and on farms, was made under contract concurrently by the Kansas Agricultural Experiment Station, Manhattan, Kansas. Results of the Kansas study will be published in a separate report.

[3] An additional study is under way to determine the costs of quality deterioration and shrinkage which will supplement the information presented in this report.

averaging 155 thousand bushels, while the typical size of farm structures was from 1,000 to 5,500 bushels.

In designing the study, emphasis was placed on determining the cost of storing corn under conditions which are typical of a modern enterprise, as opposed to the development of a cost pattern that would maximize efficiency in the performance of the storage function. Therefore, several premises are inherent in this analysis. It is assumed that the characteristics displayed by the sample of elevators and bin locations surveyed are substantially those that would be displayed if new storage facilities are built. Also, the existing level of efficiency is assumed for management and in the application of labor, power, etc., and current operating practices are assumed to continue without substantial change. Obviously, costs will be influenced by differences in any of these conditions.

No detailed analysis has been made to explain cost variations among elevator or bin units based on individual production factors. The total costs attributable to the storage function were computed, and comparisons were made on the basis of the average annual per bushel storage cost for corn. Multiple regression methods were used to measure the extent of the relationship between storage costs for given time periods, and (1) the volume of corn stored, (2) the unused storage capacity,[4] and (3) the frequency and volume of grain moved into and out of storage during the period. The procedure also makes it possible to establish probable costs in terms of each of these variables when the others are held constant. While the study confirms the usual concept of cost changes with changes in each of these factors, it also provides information with respect to the magnitude of the effect of each of the variables on storage costs.

Production, Utilization, and Storage of Corn

Production and Utilization

Corn production is greater in the north central and northwestern parts of the State than in the other areas, as is indicated in table 2 and figure 1. Total production varies from year to year, depending upon the weather and moisture conditions, but the proportion produced by each district within the State remains quite constant. Space provided for storage of corn has followed much the same pattern of concentration as does production, since most corn is utilized as livestock feed and, wherever possible, a supply is held on or near farms for this purpose. In Iowa 83.1 percent of the 1949 corn crop was fed on farms as silage or grain, while 16.9 percent was used as seed or by industry in the production of corn products such as breakfast foods, starch, industrial alcohol, and commercial feeds.[5] During the 5 years 1948-49 through 1952-53, an average of 88 percent of the corn produced in the United States was fed on farms, and 12 percent was used for seed and industrial purposes.[6]

Storage of Corn Under the Price Support Program

Most of the long-term stocks of corn are owned by Commodity Credit Corporation at the present time.

Corn which eventually may become the property of CCC under terms of the price support program is stored as ear corn in farm cribs the first year after harvest, where

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[4] See Definitions, p. 59.
[5] Jennings, R. D. Feed Consumed by Livestock, Supply and Disposition of Feeds, 1949-50, by States, U. S. Dept. Agr. Statis. Bull. 145, 74 pp., illus. June 1954.
[6] United States Agricultural Marketing Service. Feed Statistics, Including Wheat--Rye--Rice, U. S. Dept. Agr. Statis. Bull. 139, 57 pp. January 1954.

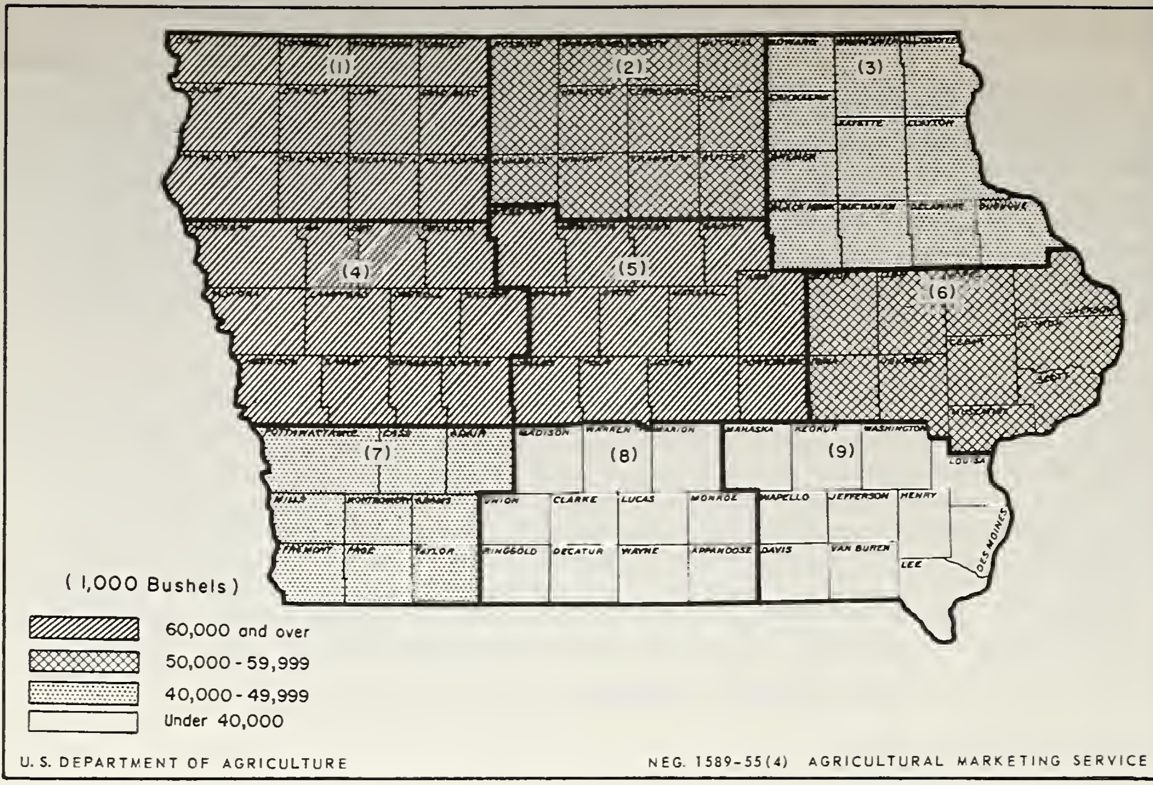

Figure 1. --Production of the 1950 crop of corn by crop reporting districts in Iowa.

TABLE 2.--Corn, all: Production in Iowa, averages 1940-44 and 1945-49, annual 1950, 1951, and 1952

Crop reporting district	Production					Percentage distribution				
	Average		1950	1951	1952	Average		1950	1951	1952
	1940-44	1945-49				1940-44	1945-49			
	1,000 bushels	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1........	79,530	78,516	63,685	61,765	101,446	14.8	14.8	13.4	13.9	14.5
2........	65,256	64,227	59,284	59,261	94,576	12.2	12.1	12.5	13.4	13.6
3........	47,062	46,814	43,553	44,811	64,886	8.8	8.9	9.2	10.1	9.3
4........	87,898	80,466	73,692	65,806	100,468	16.4	15.2	15.5	14.8	14.3
5........	85,419	84,451	72,426	76,806	111,761	15.9	15.9	15.2	17.3	16.0
6........	58,209	62,202	54,934	57,845	82,033	10.9	11.8	11.6	13.1	11.8
7........	48,988	46,849	47,203	29,042	58,741	9.1	8.9	9.9	6.6	8.4
8........	27,202	27,130	25,779	16,982	34,570	5.1	5.1	5.4	3.8	5.0
9........	36,270	38,822	34,647	30,945	49,308	6.8	7.3	7.3	7.0	7.1
Total..	535,836	529,477	475,203	443,265	697,792	100.0	100.0	100.0	100.0	100.0

drying (natural or artificial) takes place.[7] Farmers place this corn under price support either by obtaining a nonrecourse loan on it ("sealing" the corn on the farm) or by taking a purchase agreement contract on it. Neither of these mature until July 31 of the year following harvest. CCC takes title to the corn only if the farmer decides to deliver the corn in payment of his loan at maturity or in fulfillment of his purchase contract. Corn taken over by the CCC has been stored by the farmer at least 1 marketing year and has been shelled by the farmer before delivery. After delivery to the Government it is stored at bin sites[8] or in commercial elevators.

In years when the market price fails to rise above the current loan rate, unusually large quantities of corn are acquired by CCC. Lack of off-farm facilities in which this corn can be stored has resulted in "reseal" programs whereby the loan held by the producer is renewed and the corn remains on the farm.

The quantity of corn and its grade is determined when it is placed under loan on the farm, and when the loan is repaid or the corn is delivered to CCC. Since the corn is the property of the producer during the time it is stored on the farm, any damage or loss in value is borne by the farmer.

Corn stored in CCC bins is under the direct supervision of the ASC Committee of the county where the bin site is located. Bins and corn are subject to periodic inspection, and any damage to the corn becomes a loss to the Government.

Corn placed in elevators by the CCC is under the management of the elevator, subject only to provision that the elevator furnish to the CCC the same grade of corn originally turned over to it. The Government does not require that the identity of the corn be preserved by the elevator.

CCC-owned grain may be placed in public grain elevators for storage according to the contract terms of the Uniform Grain Storage Agreement. This contract provides that in return for payment, the elevator owner will provide the Government with bonded storage, generally on a commingled basis, conditioning and insurance on the grain, as well as loading in and out.

On October 1, 1952, as shown in figure 2, approximately 20 million bushels of CCC-owned corn were stored in elevators and about 140 million bushels at bin sites. This included corn from crops produced during the years 1948 through 1950. During 1952, storage space was provided on Iowa farms for nearly 170 million bushels of price support corn.

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[7] Regulations permit farmers to place under price support corn which has been dried artificially and stored as shelled corn, either in a farm bin or at country elevators. However, this practice is rare in Iowa.

[8] Beginning in 1948, the Government purchased bins for the storage of CCC-owned grain and located the bins on sites of land leased by CCC for the purpose. These bin sites are commonly found in areas where producers deliver large quantities of grain to the Government under terms of the price support program. In Iowa there may be from 2 to 20 bin sites in a county with from 2 to more than 100 bins erected at a site. Capacity of the bins ranges from 2,000 to 60,000 bushels of shelled corn, but the bin most commonly used has a capacity of about 3,000 bushels.

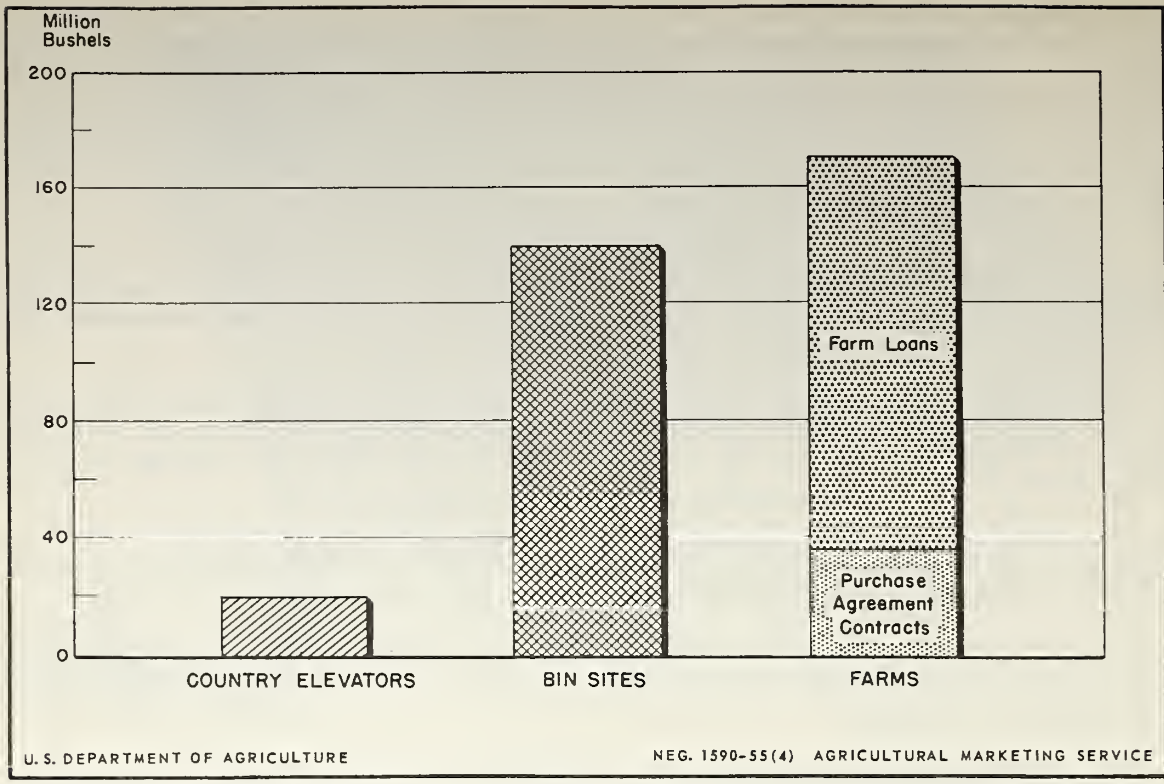

Figure 2. --CCC-owned corn stored in elevators and at bin sites as of October 1, 1952, and corn held on farms under price support program during 1952

STORAGE COSTS IN COUNTRY ELEVATORS

Most of the 20 million bushels of Commodity Credit Corporation corn in storage in country elevators in Iowa in 1952 was produced in 1948 and placed in elevator storage in the fall of 1949 under the terms of the Uniform Grain Storage Agreement.

On December 31, 1951, there were 799 bonded grain warehouses in Iowa. Elimination of terminal and subterminal elevators, as well as feed stores, seed houses, and processing plants left approximately 650 bonded country elevators which normally store grain for producers and for the Government under the price support program.

Population and Sample

This population of 650 elevators was reduced to 163 by eliminating those which had not constructed bulk grain storage space since 1946, and those which did not have a bulk grain licensed capacity[9] of 40,000 bushels or more. Small elevators were excluded to eliminate those where commercial storage is a very minor part of the total operation. The population contained cooperative, independent and line houses in proportions quite typical of the entire 650.

The elevators were divided by type of construction into three groups--concrete, wood, and steel. Concrete elevators for the most part are complete units with headhouse and tanks built into one structure. Often the old ironclad wood crib elevator is still operated as a supplement to the concrete structure. Usually, the concrete unit serves as the storage house and the older wood unit as the work house.

[9] See Definitions, p. 59.

The wood elevators in the group studied generally consist of an older elevator and a new annex also of wood construction and clad with corrugated iron. The annex in such structures is normally used as the storage unit and is served from the original headhouse. Auger conveyors at the top and bottom of the annex are typical. This arrangement provides adequate turning and handling facilities without the installation of an additional headhouse.

The elevators which were in the steel construction classification are of two types. Some are basically wood crib elevators with added storage space of quonset-type or other flat steel construction. As it is impracticable to handle grain in these structures from a central headhouse, trucks and portable augers are usually used for moving the grain. Others in this classification consist of large, bolted steel tanks which are so situated and equipped that they can be served from the elevator headhouse. In most cases, these tanks have been built around an older wood crib elevator. However, in a few cases they are combined with a new steel beam headhouse to form a complete unit.

The elevators in the group-studied were stratified by licensed bulk warehouse capacity into groups, as shown in table 3. There were no steel or wood elevators with capacities in excess of 385,000 bushels; these elevators were concentrated in the lower-capacity classifications. In both cases the lowest-capacity group was subdivided into licensed capacities from 40,000 to 60,000 bushels, and over 60,000 but under 90,000 bushels.

TABLE 3.--Population and sample of country elevators having more than 40,000 bushels storage capacity and with some construction since 1946

Type of storage construction	Licensed storage capacity (1,000 bushels)							
	40-60	40-89	61-89	90-159	160-259	260-385	Over 385	Total
Population:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Concrete...............	--	5	--	8	8	12	2	35
Steel..................	22	--	14	15	3	6	0	60
Wood...................	21	--	22	20	4	1	0	68
Total................		84		43	15	19	2	163
Sample:								
Concrete...............	--	2	--	3	3	4	1	13
Steel..................	6	--	4	3	1	2	0	16
Wood...................	4	--	4	4	2	1	0	15
Total................		20		10	6	7	1	44

A sample of 45 country elevators or about 28 percent of the population was selected, with approximately the same number of elevators in each of the 3 construction types. Sample elevators within each class were selected at random,[10] and usable schedules were obtained from 44 or the 45 elevators. All but three of these elevators had CCC corn in storage during the period studied, and most of them also had grain in store for farm producers and for grain processors.

[10] Selection was made with Snedecor's random number tables. See Snedecor, George. Statistical Methods, pp. 10-13.

Determination and Allocation of Costs

All information on country elevators was obtained by personal visit to each elevator in the sample. In those cases where the local elevator in the sample was a branch plant of a line elevator, the home office was also visited to get complete data on the elevator.

In the determination of costs associated with storage, country elevators were recognized as joint cost enterprises with certain cost items shared by the principal operations of grain merchandising, grain storage, and sideline sales. After the cost items directly traceable to grain storage were ascertained, it was necessary to apportion the joint and overhead costs equitably among the three principal operations.

The major storage costs in country elevators and the methods used to determine them are as follows:

Depreciation

Actual construction or purchase costs on buildings and equipment were obtained from elevator records and were used as a basis for depreciation. The schedule set up on the records of each elevator was used to obtain depreciation rates. In all cases this was a "straight-line" schedule which typically was 2 percent per year on concrete and steel houses, 3 percent on wood crib elevators, and from 5 to 20 percent on equipment, depending upon its expected life.

In allocating depreciation costs to the three elevator departments, each building was listed separately and its use indicated on a building cost and depreciation schedule. Buildings and pieces of equipment which were used in one specific department offered no allocation problem. For facilities used in more than one department, the allocation of costs was determined by the proportion of time the space was utilized by each operation during the year studied. Costs associated with equipment, such as the elevator leg, hoist, and loading machinery were allocated on the basis of the relative number of bushels of grain handled in each department. Office building and equipment expenses were allocated on the basis of the manager's estimate of the relative usage for each department.

Property Taxes and Insurance on Buildings and Equipment

Information on property taxes was obtained directly from elevator records. Coverage, rates, and premiums paid on insurance were taken from the insurance policies. These costs were allocated in the same manner as depreciation.

Interest on Buildings and Equipment

Interest paid on borrowed money as shown on elevator accounting records was not included in the total cost figures. The use of actual interest paid would have distorted this cost element, as elevator records disclosed that special consideration in individual cases resulted in a variance in actual interest paid from none to substantially more than 5 percent of the depreciated value of fixed assets. For this reason, all elevators were charged with interest on the depreciated value of all buildings and equipment at 5 percent. Allocation of interest among the departments was also made in proportion to the use made of the buildings and equipment.

Wages and Salaries

Payments for labor were taken directly from the payroll records of each elevator and estimates by the manager of the amount of time the employee spent in storage operation. In a few cases, where the elevator manager was also the owner and received no stipulated salary, an approximate figure was obtained based upon the compensation for similar positions in other elevators.

Allocation was accomplished by dividing the time of each employee among the three departments and allocating his total for the year accordingly. This division of time was not made for the year as a whole but on the basis of functional quarters. These quarters were as follows: July, August, and September, the heavy small grain months; October, November, and December, the heavy soybean and corn months; January, February, and March, months of continued corn movement and heavy months for feed and coal; April, May, and June, heavy months for sidelines, such as seed, fertilizer, and feed. These data, together with actual wage payments, provided the necessary information to determine storage labor costs, including payroll taxes, chargeable to grain storage.

Electricity

The manager's estimate of the number of hours each piece of power equipment was used was obtained and converted to kilowatt hours. This was done by computing the full-load kilowatt hours per hour from the rated horsepower of each motor and multiplying by the estimated number of hours used. The kilowatt hours thus computed were totaled for the entire elevator and for each department. Power cost chargeable to the grain storage operation was estimated by multiplying the total expenditures for power in the period studied by the fraction of the total allocated to the grain storage operation.

Insurance on Stocks of Grain

Premiums paid for insurance on grain stocks represent funds actually disbursed during the accounting year and do not necessarily cover the grain held in the elevator during this period. Therefore, adjustments were made to reflect insurance expense chargeable to grain stored for the period under study. Allocation of this expense was made among departments on the basis of the ratio of the average monthly inventory of storage stocks to the average monthly inventory of merchandised grain stocks.

Other Costs

Such expenses as elevator supplies and repairs, transportation, and communication were obtained from elevator records and allocated to the proper department with the help of the manager or some other key employee. In general, overhead costs such as audit expenses and directors' fees were allocated to departments through the use of the ratio used in allocating office building and equipment depreciation costs to the three operations. This ratio was also used, for line companies, to divide the costs of the home office allocated to the local elevator.

The total annual cost and the allocation to the three departments by elevator is shown in table 4. These figures represent the allocation of total annual costs resulting from the procedure described above. A comparison of the costs allocated to the three departments reveals that for most of the elevators all three represent sizable operations. However, in the main the grain storage operation is less important than sidelines and grain merchandising in terms of total annual cost.

Factors Which Affect Elevator Storage Costs

Considerable variation in total annual storage costs was observed among the 44 country elevators, ranging from $1,740 for elevator number 19 to $38,070 for elevator number 14, with an average of $8,430 for all elevators studied (see table 5). In order to estimate storage costs for elevators other than those studied, and for periods other than that covered by the study, it was necessary to isolate the major factors causing this variation in storage cost. The following factors were examined to see if they were related to annual storage cost in the sample elevators and to determine which should be included in the regression equation: (1) Type of storage structure, (2) volume of corn stored, (3) amount of unused capacity, (4) bushels placed in storage, and (5) bushels taken out of storage.

TABLE 4.--Allocation of total annual grain elevator costs, by operations

Elevators, by type of structure	Total cost	Costs allocated to--		
		Grain merchandising	Sidelines	Storage
	Dollars	*Dollars*	*Dollars*	*Dollars*
Concrete:				
No. 1	$23,571	$12,896	$6,526	$4,149
No. 2	22,762	7,666	8,980	6,116
No. 3	75,168	25,251	39,459	10,458
No. 4	44,424	14,460	19,727	10,237
No. 5	36,866	16,431	12,627	7,808
No. 6	59,202	23,597	23,436	12,169
No. 7	66,070	23,366	30,066	12,638
No. 8	28,038	9,052	7,402	11,584
No. 9	67,040	24,856	25,825	16,359
No. 10	93,799	34,928	42,728	16,143
No. 11	37,194	4,729	9,805	22,660
No. 12	38,476	12,270	13,655	12,551
No. 14	114,027	39,159	36,799	38,069
No. 30	46,961	20,152	10,092	16,717
Average[1]	53,827	19,200	20,509	14,118
Wood:				
No. 31	28,995	9,244	14,402	5,349
No. 32	19,072	8,309	7,074	3,689
No. 33	34,780	12,740	18,943	3,097
No. 34	18,522	7,776	7,709	3,037
No. 35	26,281	11,697	9,170	5,414
No. 36	11,093	4,402	None	6,691
No. 37	28,600	12,935	10,305	5,360
No. 38	75,950	23,245	39,494	13,211
No. 39	17,838	10,505	2,893	4,440
No. 40	33,508	10,443	16,688	6,377
No. 41	18,842	7,384	4,267	7,191
No. 42	45,182	39,095	None	6,087
No. 43	39,482	10,517	17,358	11,607
No. 44	18,801	3,471	6,892	8,438
No. 45	21,200	8,834	None	12,366
Average[1]	29,210	12,040	10,346	6,824
Steel tank:				
No. 13	43,263	14,537	23,877	4,849
No. 21	13,203	6,978	3,596	2,629
No. 22	46,864	16,763	23,858	6,243
No. 27	24,496	8,845	9,047	6,604
No. 28	59,232	13,285	37,798	8,149
No. 29	47,813	10,076	24,104	13,633
Average[1]	39,145	11,747	20,380	7,018
Flat steel:				
No. 15	24,506	8,965	13,226	2,315
No. 16	52,511	13,429	35,870	3,212
No. 17	23,830	9,494	12,294	2,042
No. 18	26,986	9,482	15,181	2,323
No. 19	20,289	7,957	10,597	1,735
No. 20	16,595	3,954	10,513	2,128
No. 23	14,187	3,573	6,683	3,931
No. 24	98,036	51,103	41,090	5,843
No. 26	18,210	8,285	4,805	5,120
Average[1]	32,794	12,916	16,695	3,183
Average of 44 elevators	39,132	14,458	16,247	8,427

[1] These are simple arithmetic averages and should not be interpreted as a direct measure of comparative efficiency between elevator groups.

TABLE 5.--Storage volume and annual storage costs for 44 country grain elevators in Iowa

Elevators, by type of structure	Grain stored--average monthly inventory	Storage space unused	Grain put in storage	Grain taken out of storage	Total storage cost	Annual cost per bushel
Concrete:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Dollars*	*Cents*
No. 1............	45,903	18,100	1,850	1,120	$4,150	9.04
No. 2............	83,300	0	0	0	6,120	7.34
No. 3............	22,371	77,630	71,700	74,780	10,460	46.75
No. 4............	94,846	48,150	0	17,000	10,240	10.79
No. 5............	97,133	7,870	0	93,860	7,810	8.04
No. 6............	176,447	10,550	6,900	26,430	12,170	6.90
No. 7............	165,510	8,490	14,140	82,890	12,640	7.64
No. 8............	166,819	20,180	18,630	0	11,580	6.94
No. 9............	296,319	16,680	0	53,830	16,360	5.52
No. 10............	164,480	85,520	14,630	0	16,140	9.81
No. 11............	351,913	2,090	13,580	83,260	22,660	6.44
No. 12............	230,248	29,750	7,150	3,260	12,550	5.45
No. 14............	642,676	37,320	0	99,280	38,070	5.92
No. 30............	320,995	1,010	0	0	16,720	5.21
Average.........	204,211	25,950	10,620	38,270	14,120	[1] 6.91
Wood:						
No. 31............	20,500	18,500	15,330	28,210	5,350	26.09
No. 32............	22,074	22,930	0	0	3,690	16.71
No. 33............	14,925	27,280	0	0	3,100	20.75
No. 34............	34,029	7,970	0	19,490	3,040	8.92
No. 35............	3,806	52,190	14,780	8,280	5,410	142.25
No. 36............	39,237	22,760	34,020	0	6,690	17.05
No. 37............	63,726	17,270	26,460	0	5,360	8.41
No. 38............	180,252	31,750	0	5,000	13,210	7.33
No. 39............	45,826	27,170	0	0	4,440	9.69
No. 40............	43,617	20,380	42,310	12,820	6,380	14.62
No. 41............	47,091	16,910	25,000	25,000	7,190	15.27
No. 42............	56,250	18,750	28,720	33,710	6,090	10.82
No. 43............	147,763	32,240	3,770	2,200	11,610	7.86
No. 44............	144,952	0	0	0	8,440	5.82
No. 45............	194,917	5,080	10,610	0	12,370	6.34
Average.........	70,598	21,410	13,400	8,980	6,830	[1] 9.67
Steel tank:						
No. 13............	37,717	18,280	14,550	4,720	4,850	12.86
No. 21............	16,832	40,170	0	0	2,630	15.62
No. 22............	40,064	17,940	37,650	0	6,240	15.58
No. 27............	84,000	0	0	0	6,600	7.86
No. 28............	147,922	4,080	0	0	8,150	5.51
No. 29............	192,275	26,730	73,830	0	13,630	7.09
Average.........	86,468	17,870	21,000	790	7,020	[1] 8.12

TABLE 5.--Storage volume and annual storage costs for 44 country grain elevators in Iowa--Continued

Elevators, by type of structure	Grain stored--average monthly inventory	Storage space unused	Grain put in storage	Grain taken out of storage	Total storage cost	Annual cost per bushel
Flat steel:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Dollars*	*Cents*
No. 15............	34,332	0	0	0	2,320	6.74
No. 16............	39,553	0	0	0	3,210	8.12
No. 17............	36,373	0	0	0	2,040	5.61
No. 18............	33,705	0	0	0	2,320	6.89
No. 19............	25,000	27,000	0	0	1,740	6.94
No. 20............	36,970	9,230	0	0	2,130	5.76
No. 23............	53,208	2,940	34,890	0	3,930	7.39
No. 24............	87,712	0	0	0	5,840	6.66
No. 26............	122,000	0	0	0	5,120	4.20
Average.........	52,095	4,350	3,880	0	3,180	[1] 6.11
Average of 44 elevators.....	111,491	18,880	11,600	15,340	8,430	[1] 7.56

[1] Weighted by the average monthly inventory for the group.

Type of Construction

Annual per bushel storage costs were computed for each type of construction, as shown in table 6.

TABLE 6.--Storage costs per bushel, weighted annual average, by type of elevator construction

Construction of elevator	Number of elevators	Weighted annual average per bushel storage costs
		Cents
Wood..	15	9.67
Steel tank..	6	8.12
Concrete..	14	6.91
Flat steel..	9	6.11
Total...	44	7.56

The apparent difference in the per bushel storage costs between the groups of elevators in table 6 is not necessarily significant because of the confounding of other variables affecting storage costs between the groups. A statistical analysis of covariance was not made, since differences in costs between elevator groups were examined in the multiple regression analysis, the results of which are discussed on page 17.

Average Monthly Inventory[11]

The country elevator storage cost figures were also examined to see what relationship existed between annual storage costs and average monthly storage inventory in the 44 elevators studied (see table 7). A continuous decrease in annual per bushel storage cost is observed as the bushels of average monthly inventory increase with the exception of the 101,000 to 150,000 bushel volume range. In the case of the four elevators included in this group, cost factors other than size of inventory were important enough to reduce unit costs below those which might be expected in this analysis. A more complete analysis of the effect of average monthly inventory on storage costs is reported on pages 17-18.

TABLE 7.--Storage costs per bushel, weighted annual average, by average monthly inventory

Average monthly inventory	Number of elevators	Weighted annual average storage costs per bushel
1,000 bushels	*Number*	*Cents*
0 - 25	7	25.80
26 - 50	13	10.70
51 - 100	8	8.74
101 - 150	4	5.92
151 - 200	7	7.09
201 and over	5	5.77

Utilization of Capacity

In order to examine the relationship between annual per bushel storage costs and the amount of storage capacity which was used, the 44 elevators were grouped by percentage of storage capacity utilized, as shown in table 8. Percentage utilization, unlike total unused capacity, is independent of the storage capacity in each elevator. Therefore, when per bushel costs are compared, percentage utilization is more meaningful than total unused capacity.

TABLE 8.--Storage costs per bushel, weighted annual average, by percentage of capacity in use

Percentage of storage capacity in use	Number of elevators	Weighted annual average storage costs per bushel
	Number	*Cents*
91 - 100	18	6.17
81 - 90	8	7.56
71 - 80	5	10.04
61 - 70	6	11.04
51 - 60	1	26.09
41 - 50	2	11.52
31 - 40	1	20.76
21 - 30	2	33.38
11 - 20	--	--
1 - 10	1	142.25
Average 85.5	....	7.56

[11] See Definitions, p. 59.

Some relationship between storage costs and the degree of utilization of storage capacity is indicated in table 8. The elevators having the lowest annual per bushel costs were those in which storage space was most fully utilized, and those with the highest costs were those in which storage space was least effectively utilized. This relationship does not hold between all groups in table 8, however. See pages 18-20 for statistical analysis.

Storage Turnover

In order to examine the elevator storage costs to see to what extent they may be affected by the volume of grain put into and taken out of storage during the year, the elevators were grouped as shown in table 9. Percentage of storage turnover is obtained for each of the 44 elevators by first adding the bushels put into storage and bushels taken out of storage during the year and dividing by 2, and then computing what percentage the resulting figure is of the average storage inventory for that elevator.

TABLE 9.--Storage costs per bushel, weighted annual average, by elevator storage turnover

Percentage of storage turnover	Number of elevators	Weighted annual average storage costs per bushel
	Number	*Cents*
0 - 6	24	6.85
7 - 25	7	4.97
26 - 50	7	9.68
51 -110	4	14.94
111-300	0	--
301-400	2	60.63
Average 12.1	....	7.56

Because costs are incurred in moving corn into and out of storage, one would expect annual storage cost per bushel to increase as the percentage of storage turnover increases. Some indication of this relationship is observed in table 9, but it does not hold between all elevator groups shown in this table. This relationship was not examined by covariance analysis since the two measures of storage turnover--bushels placed into storage and bushels taken out of storage--were included as independent variables in the multiple regression equations. The relationship is discussed on pages 21-23.

Relationship Between Storage Cost and Measure of Volume

For this analysis, the regression equation was stated in terms of total annual storage cost as a function of the following measurements of volume: (1) Average bushel storage inventory, (2) bushels of unused storage capacity, (3) bushels put into storage during the year, and (4) bushels taken out of storage during the year. The model used was $\hat{Y} = b_1X_1^{.8} + b_2X_2 + b_3X_3 + b_4X_4$. The selection of this model is based primarily on theoretical considerations as discussed in the appendix.[12] The elevators of each of the four types of construction were considered separately. For this purpose, the figures shown in table 5 were used.

[12] The regression equations were computed in terms of total costs and total volumes rather than in terms of per bushel costs and volume ratios for unused capacity and storage turnover, primarily because the regression formula and computational procedure were much less complex with the equations stated in totals.

Solution of the 4 equations by the method of least squares revealed that cost relationships between the elevators of the 4 types of construction were not significantly different. Consequently, 1 multiple regression equation was determined for the 44 elevators. This single equation shows the relative importance of each of the 4 measures of volume in determining total annual storage costs, and explains about 99 percent of the variation in total annual storage cost among the sample elevators.

The scatter diagram shown in figure 3 graphically illustrates the statement that most of the variation in costs has been explained by the regression equation. In this figure, total annual storage costs have been plotted on the vertical axis against the bushels of average monthly storage inventory on the horizontal axis. Any point on the curve gives the estimated total annual storage cost associated with a particular volume of average storage inventory, assuming full utilization of storage capacity and no movement into and out of storage.

The dots dispersed around the curve in figure 3 represent the actual observed storage costs for each of the 44 elevators after the costs were adjusted for variations in the amount of unused capacity and bushels placed into and taken out of storage. The regression equation was used to compute these adjustments. Therefore, if 100 percent of the variation in storage costs were explained by the equation all of the dots would have fallen on the curve. As indicated from the key on the diagram, the differently shaped dots indicate the dispersion for each type of elevator separately. Examination of dots for the 4 elevator types indicates that they fall quite closely around the total cost curve for all 44 elevators.

It is usually more meaningful to elevator operators and others interested in elevator storage costs to report annual storage costs in per bushel figures rather than in total figures. Therefore, estimated annual storage costs in country elevators are reported on a per bushel basis in figure 4. This curve also assumes full utilization of capacity and no movement into and out of storage. Per bushel costs at any storage volume may be computed from the estimated total storage costs of the regression equation by dividing the total cost by the number of bushels stored.

Influence of Size of Storage Capacity Upon Costs

Estimated annual storage costs in country elevators at increasing storage capacities are shown in table 10 and figure 5. These costs have been computed from the regression equation at 3 degrees of capacity utilization--50, 75, and 100 percent.[13] They are based on an average length of storage of two years.

Table 10 shows that the estimated annual cost per bushel of storage in country elevators decreases as the size of the storage operation increases. At 100 percent utilization of storage capacity, per bushel costs decrease from 11.50 cents at 25,000 bushels capacity, to 8.54 cents at 200,000 bushels, to 7.42 cents at 600,000 bushels storage capacity. The same general relationship is also apparent at 75 and 50 percent utilization of capacity, as shown in table 10.

In figure 5 estimated annual storage costs per bushel have been plotted on the vertical axis against bushels of storage capacity on the horizontal axis. The 3 curves show the relationship between these factors at the 3 different degrees of utilization of storage capacity. They indicate that storage costs decline most rapidly at the smaller storage

[13] This computation was made from regression equation (2), $\hat{Y} = .165\, X_1^{.8} + .062\, X_2 + .022\, X_3 + .035\, X_4$ by substituting storage capacity (X) multiplied by the appropriate constants for X_1, X_2, X_3, X_4. For example, at 75 percent capacity utilization, the equation used was $\hat{Y} = .165\,(.75X)^{.8} + .062\,(.25X) + .022\left(\frac{.75X}{2}\right) + .035\left(\frac{.75X}{2}\right)$. The per bushel cost was then computed by dividing the total costs by average storage inventory, i.e. $\hat{Y}/.75X$. (See Appendix p. 55.) This method of computation assumes that the elevators at each level of capacity utilization exhibit the same regression pattern as the 44 elevators in the sample.

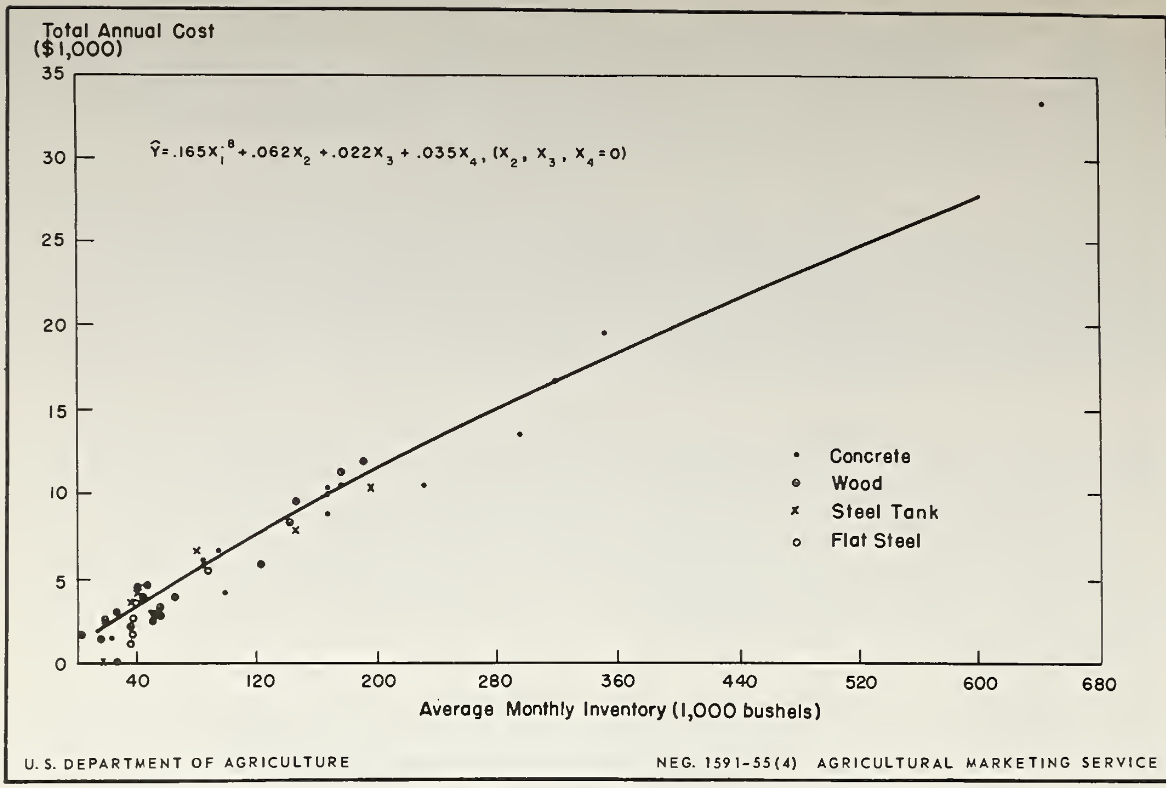

Figure 3. --Relationship between total annual storage cost and average monthly inventory in 44 country elevators, showing the scatter about the line of relationship after correcting for the effect of the other independent variables (X_2, X_3, X_4, in appendix), assuming full utilization of capacity.

volumes, with relatively stable storage costs for elevators having larger capacities (i.e., over 200,000 bushels).

Figure 5 shows the same general relationship between storage capacity and storage cost as that shown in figure 4. However, the 100-percent utilization curve in figure 5 is not identical to the curve in figure 4. The curve in figure 4 considers no grain moved into or out of storage during the year, while all three curves in figure 5 consider the amount of grain moved into and out of storage during the year to be half of the storage inventory.

Storage Costs Increase as Degree of Utilization Decreases

The inverse relationship between estimated annual per bushel storage cost and the degree of utilization of storage capacity can be seen clearly in table 11 and figure 6. In table 11, the average length of storage considered is also 2 years, but the degree of utilization shown in the first column varies by 10 percentiles from 100 percent to 50 percent. Four different storage capacities are considered, as shown across the top of the table.[14]

[14] This computation was made from regression equation (2), $\hat{Y} = .165X_1^{.8} + .062X_2 + .022X_3 + .035X_4$ by substituting the appropriate values for the independent variables, X_1, X_2, X_3, X_4. For example, at 60 percent utilization of capacity of 100,000 bu., the equation used was $\hat{Y} = .165\,[(100,000)\,(.6)]^{.8} + .062\,[(100,000)\,(.4)] + .022\left[\frac{(100,000)\,(.6)}{2}\right] + .035\left[\frac{(100,000)\,(.6)}{2}\right]$. The per bushel cost figure of 14.25 cents was obtained by dividing this total cost ($\hat{Y}$) by 60,000 bushels. (See Appendix p. 55.)

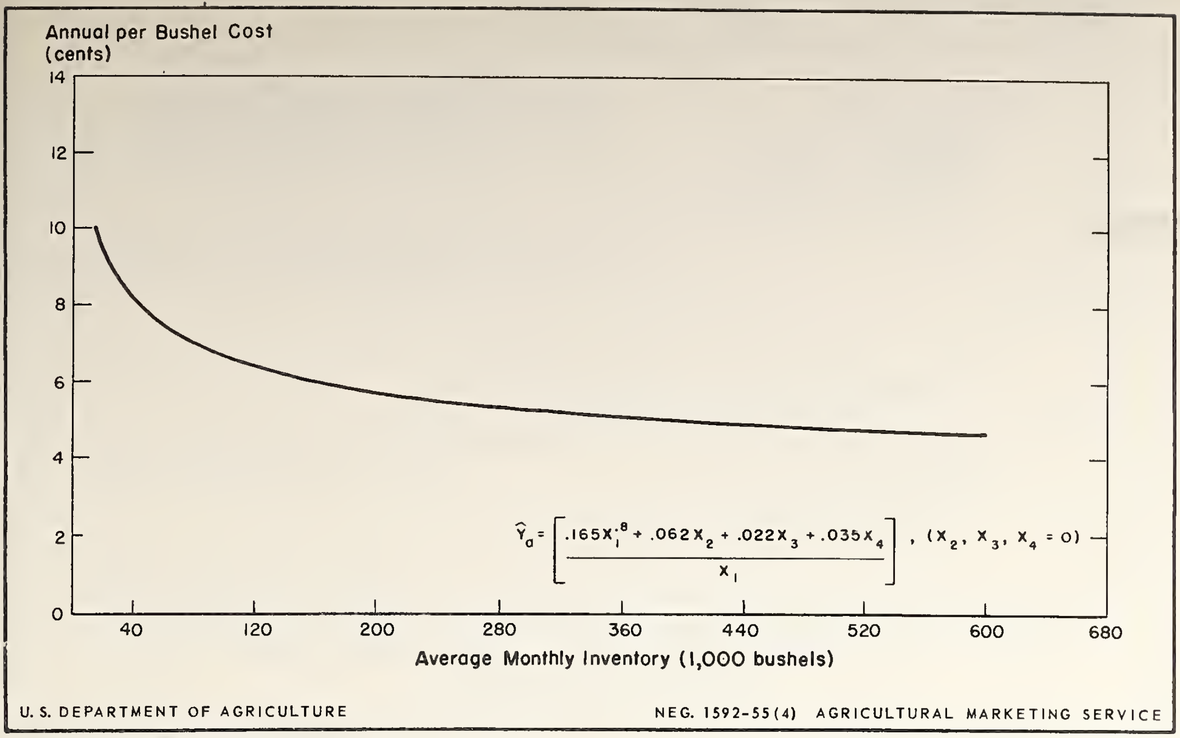

Figure 4. --Relationship between annual storage cost per bushel and average monthly inventory in 44 country elevators after effect of other independent variables (X_2, X_3, X_4, in appendix) is removed, assuming full utilization of capacity.

TABLE 10.--Annual storage costs per bushel for elevators of selected capacities with storage space utilized at 100, 75, and 50 percent of capacity (average length of storage, 2 years)

Storage capacity	Annual costs per bushel, by percentage of capacity utilized		
	100 percent	75 percent	50 percent
	Cents	*Cents*	*Cents*
25,000 bushels...........	11.50	14.08	19.00
50,000 bushels...........	10.37	12.89	17.71
75,000 bushels...........	9.79	12.27	17.04
100,000 bushels..........	9.40	11.86	16.59
125,000 bushels..........	9.11	11.56	16.26
150,000 bushels..........	8.89	11.32	16.00
175,000 bushels..........	8.70	11.12	15.79
200,000 bushels..........	8.54	10.96	15.61
250,000 bushels..........	8.30	10.69	15.33
300,000 bushels..........	8.10	10.48	15.10
350,000 bushels..........	7.94	10.32	14.92
400,000 bushels..........	7.81	10.17	14.76
450,000 bushels..........	7.69	10.05	14.63
500,000 bushels..........	7.46	9.94	14.51
550,000 bushels..........	7.50	9.85	14.41
600,000 bushels..........	7.42	9.76	14.32

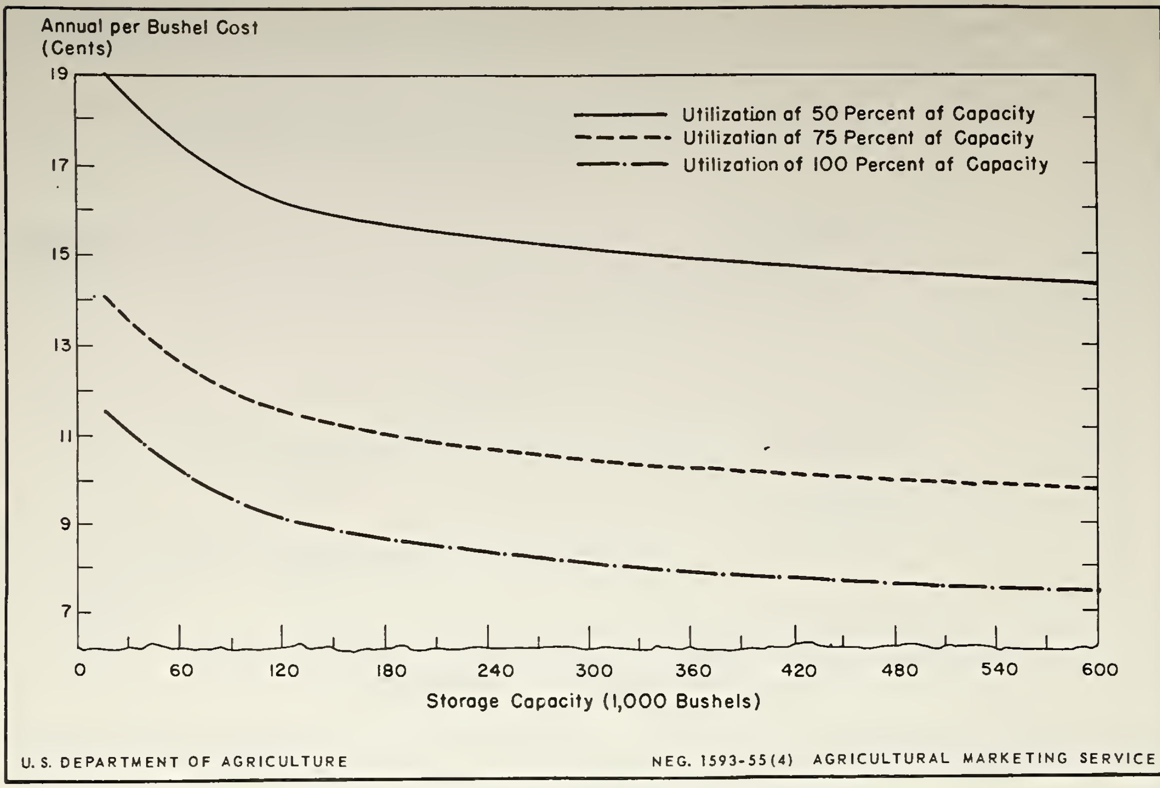

Figure 5. --Relationship between annual storage cost per bushel and storage capacity in country elevators. Average length of storage, 2 years.

At a storage capacity of 50,000 bushels, estimated storage cost varies from 10.37 cents per bushel at 100 percent utilization, to 12.28 cents per bushel at 80 percent utilization, to 17.71 cents per bushel at 50 percent utilization of capacity. A similar relationship exists at storage capacities of 100,000 bushels, 200,000 bushels, and 400,000 bushels.

TABLE 11.--Annual storage costs per bushel for elevators with capacity utilized in various degrees (average length of storage of 2 years)

Degree of utilization	Annual costs per bushel for elevators with capacity of--			
	50,000 bushels	100,000 bushels	200,000 bushels	400,000 bushels
100 percent......................	10.37	9.40	8.54	7.81
90 percent......................	11.23	10.23	9.36	8.60
80 percent......................	12.28	11.25	10.36	9.59
70 percent......................	13.60	12.55	11.63	10.84
60 percent......................	15.33	14.25	13.31	12.49
50 percent......................	17.71	16.59	15.61	14.76

In figure 6, the estimated annual per bushel storage costs have been plotted on the vertical axis against the degree of utilization of capacity on the horizontal axis. The 4 curves, representing the 4 different elevator storage capacities considered, show that

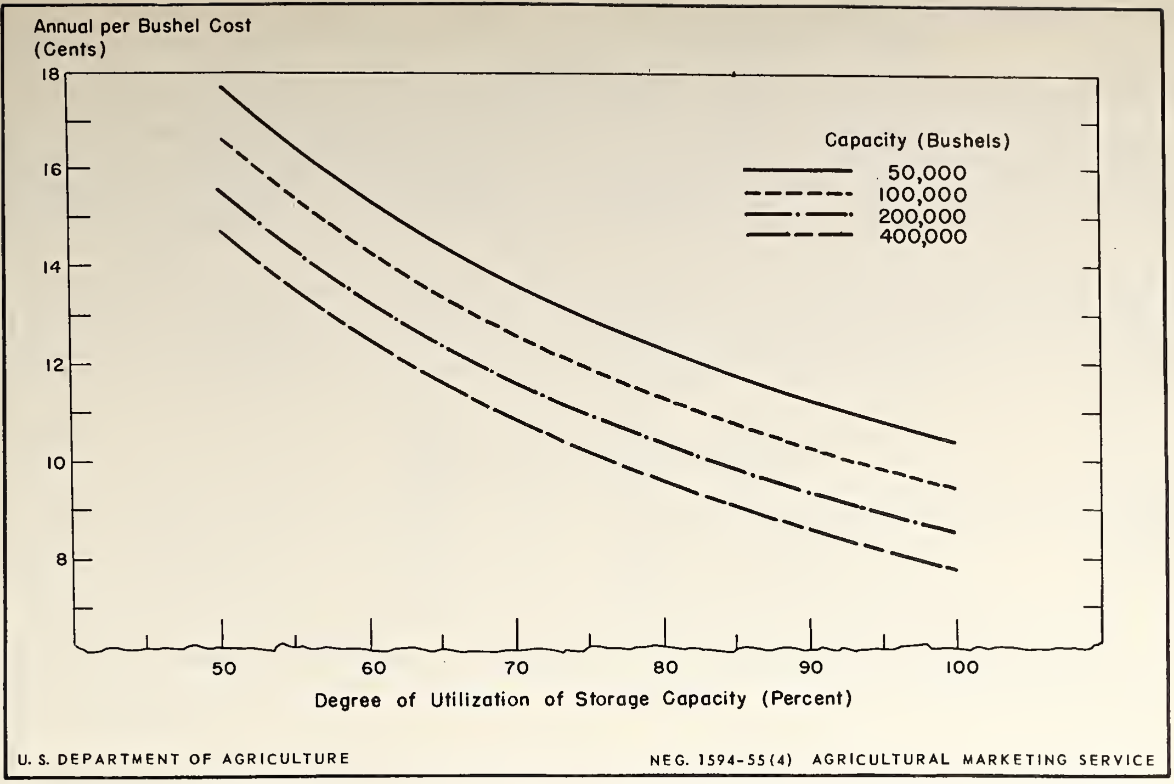

Figure 6.--Relationship between annual cost per bushel and degree of utilization of storage capacity in country elevators. Length of storage, 2 years.

storage costs decrease substantially as the degree of utilization increases. Storage costs decline most rapidly at the lower degrees of capacity utilization.

Costs Increase as Rate of Storage Turnover Increases

Because certain additional costs are incurred in moving grain into and out of elevator storage, one would expect storage costs to increase as the rate of storage turnover increases. Another way of saying the same thing is that storage costs may be expected to decrease as the length of the storage period increases. This expected relationship is definitely borne out in the annual per bushel storage costs estimated from the regression equation, as shown in table 12 and figure 7. In table 12, the degree of utilization is held constant at 90 percent, 4 different storage capacities are considered, and the average length of storage varies from 6 months to 10 years.[15] At 50,000 bushels capacity, estimated annual per bushel storage cost decreases from 19.70 cents for a 6-month storage period, to 10.29 cents for a 3-year storage period, to 8.97 cents for a storage period of 10 years. A similar relationship is shown for storage capacities of 100,000 bushels, 200,000 bushels, and 400,000 bushels.

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[15] This computation was made from regression equation (2), $\hat{Y} = .165X_1^{.8} + .062X_2 + .022X_3 + .035X_4$, by substituting the appropriate values for the independent variables, X_1, X_2, X_3, X_4. For example, at a capacity of 200,000 bushels and an average length of storage of 36 months, the equation used was $\hat{Y} = .165\,[(200{,}000)\,(.9)]^{.8} + .062\,[(200{,}000)\,(.1)] + .022\left[\frac{(200{,}000)\,(.9)}{3}\right] + .035\left[\frac{(200{,}000)\,(.9)}{3}\right]$. The per bushel cost figure of 8.42 cents was obtained by dividing this total cost ($\hat{Y}$) by 180,000 bushels. (See appendix p. 56).

TABLE 12.--Annual storage costs per bushel for elevators of selected capacities by average length of storage (90-percent of capacity utilized)

Average length of storage	Annual storage costs per bushel for elevators with storage capacity of--			
	50,000 bushels	100,000 bushels	200,000 bushels	400,000 bushels
6 months........................	19.70	18.70	17.83	17.07
12 months........................	14.05	13.05	12.18	11.42
18 months........................	12.17	11.17	10.30	9.54
24 months........................	11.23	10.23	9.36	8.60
30 months........................	10.66	9.66	8.79	8.04
36 months........................	10.29	9.29	8.42	7.66
42 months........................	10.02	9.02	8.15	7.39
48 months........................	9.82	8.82	7.95	7.19
60 months........................	9.53	8.54	7.67	6.91
72 months........................	9.35	8.35	7.58	6.72
84 months........................	9.21	8.21	7.34	6.59
120 months......................	8.97	7.97	7.10	6.34

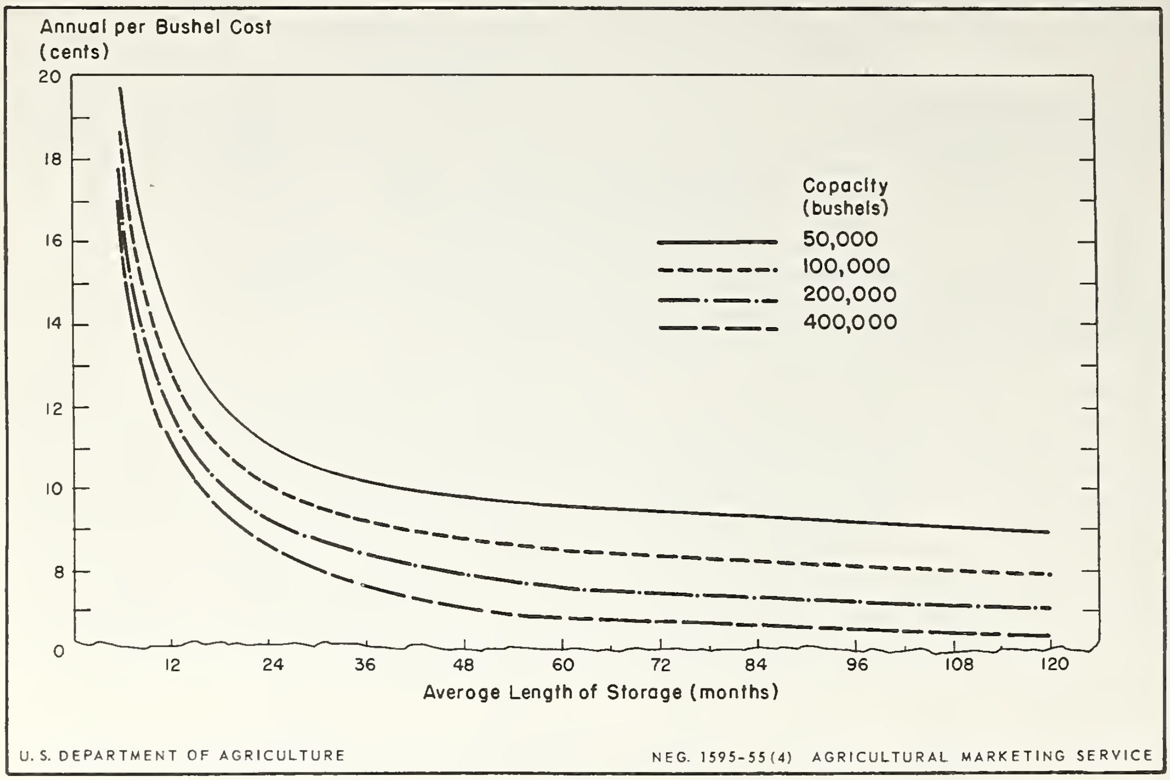

Figure 7. --Relationship between annual cost per bushel and average length of storage in country elevators, with 90 percent of capacity utilized.

Figure 7 shows the information in table 12 in graphic form. In this chart, estimated annual storage cost per bushel is plotted on the vertical axis against the computed length of storage on the horizontal axis. The 4 curves representing the 4 different storage capacities show that storage costs decrease substantially as the average length of storage

increases. The rate of decrease is much less pronounced as the computed storage period lenghthens.

It must be remembered that the actual storage period considered for all the figures shown in table 12 and figure 7 is 1 year. The computed "length of storage" simply measures the rate of inventory turnover, or the relationship between the volume of grain moved into and out of storage during the year and the average monthly inventory of grain stored for the year. The total storage cost per bushel may be computed for periods other than 1 year by multiplying the annual costs in table 12 by the number of years desired.

It should also be pointed out again that this study does not take into account storage costs arising from shrinkage or quality deterioration in the grain during storage. If it is true that costs associated with these factors are higher when corn is stored for longer periods, this would tend to offset the relationship so evident in table 12.

BIN SITE STORAGE COSTS

In contrast to some 20 million bushels of CCC-owned reserve stocks of corn in Iowa country elevators in 1952, over 140 million were stored at bin sites in Iowa during that time. The total bin site capacity was over 170 million bushels.

When corn is turned over to the Government under the price support program, it is trucked from the farm to the bin site, usually via the nearest country elevator for weighing. It is placed in the bins and subsequently removed through use of portable loading equipment.

The bin site program involves expenditures for the bins, handling equipment, and for field crew labor, as well as a certain amount of administrative overhead. These data could be obtained, together with records covering capacities of bins, quantities of grain loaded in and out, and average monthly inventories. Therefore, it was possible to compute costs of storage at bin sites in a way that would be comparable to that employed in the case of country elevators.

Population and Sample

Complete cost records are not kept by individual bin sites. Supervision, management, and record-keeping of bin site operations are maintained on a county basis. This made it necessary to define the population in terms of county units and to design the study to show the relationship of annual storage costs per bushel to county storage volume.[16]

The total population to be sampled was therefore the 100 county offices in Iowa[17] each one including all the bin sites under its jurisdiction. Six counties located along the Missouri River were excluded from the population, since some of the bin sites in each county were virtually destroyed by flood in the spring of 1952 and could not be considered typical of bin site storage for the State.

The sample consisted of 1 county selected at random in each of the 10 Agricultural Conservation and Stabilization districts in Iowa.[18] This sample placed emphasis on the relative importance of corn as a cash crop from 1 area of the State to another and assured a substantial range among the sample counties in volume of corn stored. The 10 districts as of April 1952 are shown in figure 8. The shaded county in each district is the sample county.

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[16] As a result, it was not possible to design the study to reveal the optimum bin site size from the standpoint of least cost per unit of storage.

[17] There are 99 counties in Iowa. Pottawattamie County has two Agricultural Stabilization and Conservation (ASC) county offices, which brings the total number of county offices to 100.

[18] An ASC district is a geographical area designated as an administrative unit within a State.

Determination and Allocation of Costs

Superimposed over the county administration, which was chosen as the basis of study, were district, State, regional, and national operations. Each was concerned to an extent with bin site storage, and costs incurred at each level were considered in planning the computation of costs attributable to storage at bin sites. It was determined, for the purposes of this study, that no part of the regional or Washington office expense would be charged to Iowa bin site storage operations. These offices perform about the same services in connection with both elevator and farm storage of CCC corn as they do in connection with bin site storage operations. They would probably be maintained at about the same scale if all CCC corn were stored by private interests and the Government owned no storage facilities. For this reason, no part of the cost of maintaining the regional and national CSS offices was charged to the bin site operation.

It was possible to allocate most costs between the storage function and other functions performed by the State and county offices through use of standard governmental accounting procedures. However, it was necessary to allocate State expenses for storage operations to the 10 districts and the total storage expenses in the 10 districts to the 10 counties within each district. The formula for allocating State expense to the districts placed equal weight on five factors; storage capacity, average inventory of corn stored, bushels of corn placed in bins, bushels of corn taken out of bins,[19] and the salary paid a fieldman who supervises storage work in each district under the direction of the State office. The formula for allocating district expense to the sample county in the district placed equal weight on county capacity, storage volume, movement into bins, and movement out of bins.

Cost items were obtained from the CSS Commodity Office in Chicago, Ill., and State and county ASC offices. Prices paid for bins and other information required on the bin site building cost and depreciation schedule were obtained from the CSS commodity office. However, insofar as possible, information was obtained from the records of the State ASC office. This included not only receipts, disposition and inventories of corn by bin site, but also expenses allocable to storage at the State level, salaries of the district fieldmen, and information required to formulate State and district equipment cost and depreciation schedules. The information required from the county ASC offices included labor payments and other expenditures associated with bin site storage for which disbursement was made at the county level, including payments for certain capital items. Salaries of the district bin crews and other district storage expenses (except the salary of the district fieldman) were paid through one of the county offices in the district.

Chief costs incurred in storing grain at bin sites were the storage structures, the labor that went into the physical handling of the grain, and supplies and materials incident to the program. Governmental accounting procedure provides that original cost of bins and equipment be handled as current expense. To obtain comparability with elevator accounting practice, straightline depreciation was computed on an annual basis at 5 percent of original cost on metal bins and buildings, and 10 percent on wood bins. The annual depreciation rate for office equipment and tools was 10 percent, and that for field equipment, including trucks and handling equipment was 20 percent.

No allowance is made in CSS accounts for interest on the bin and equipment investment. Therefore, a uniform 5 percent was charged against the depreciated value of the bins and equipment, just as was done in the case of country elevators.

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[19] Records on capacity, average inventory, and volume of movement in and out of bins are not kept on a district basis. District figures were estimated by taking an average of these items for three counties in each district. One of the three was the sample county. If this county was about modal volume according to the estimate of State ASC officials, the other 2 counties were those estimated to be 1 of the high and 1 of the low volume counties in the district. If the sample county was near the high in estimated volume, the other two counties were those estimated to be modal and low volume, etc.

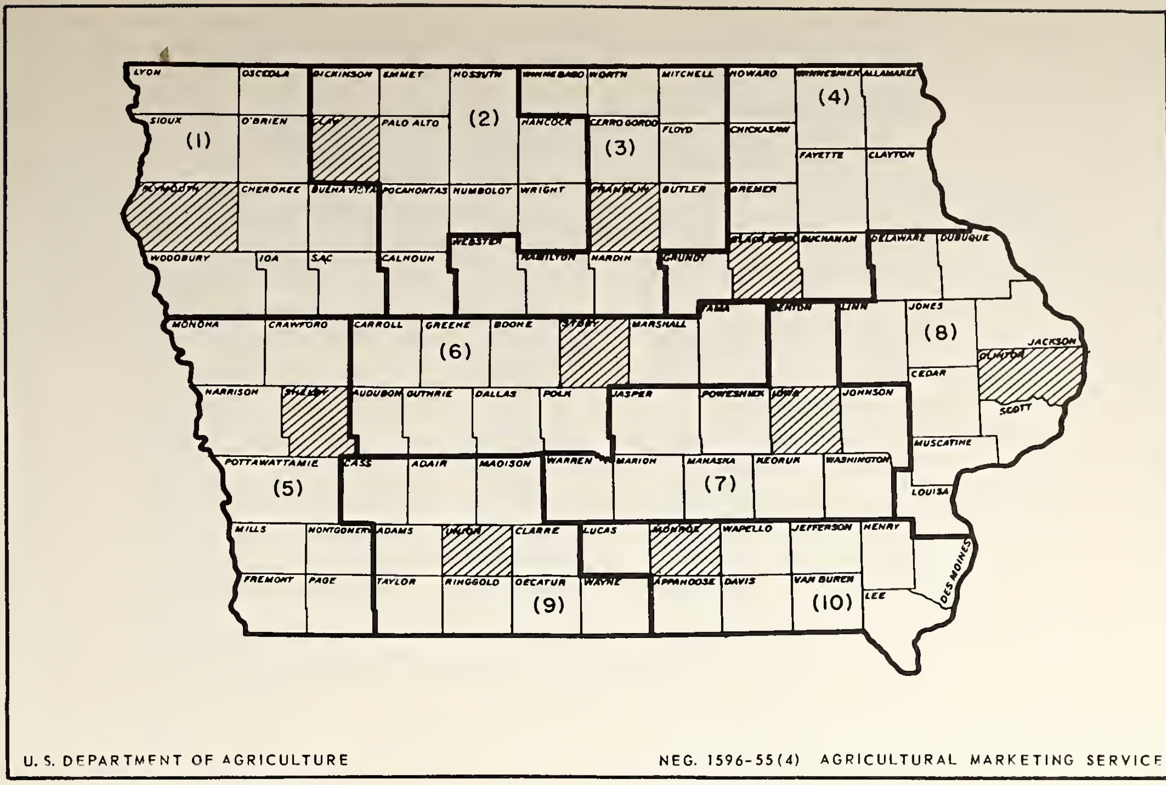

Figure 8.--Ten ASC districts in Iowa. Counties which were used as samples to study cost of storing grain at bin sites are indicated by shading.

Wages and salaries paid by the counties were an important cost item in bin site storage. Services for which wages were paid included the placing of the corn in the bins, conditioning it where necessary, and removal of the grain. Wage payments disbursed at the district or State level were prorated to the sample counties according to the formula described above.

Other expenses allocated to bin site storage included supplies and materials, office expenses, travel, maintenance and repairs, and miscellaneous other items.

Table 13 shows "incurred" storage costs for each county determined according to the methods outlined above. Counties are arranged in column 1 by size of inventory, with County 6, which had the largest quantity of corn in storage, heading the list. Total bin site storage costs are given, together with the amounts which were incurred at county, State, and district levels. The last column shows the annual cost of storage per bushel, weighted by inventory, for each county, and an average for the State; these costs are also referred to in this study as the "unadjusted" costs of storage at bin sites.

Adjustments in Bin Site Storage Costs

Storage costs were adjusted[20] to include certain cost items for which the Government makes no direct disbursement. This adjustment was made so that costs of storage at bin sites, and costs which would be borne by private enterprise, would be comparable. CSS accounting procedure made no allowance for insurance on bins or their contents, or for property and excise taxes. These items represent important costs in the case of commercial storage. For comparative cost purposes, therefore, insurance and taxes were computed as explained below.

[20] See Definitions, p. 59.

TABLE 13.--Total incurred costs chargeable to bin-site storage program and annual storage cost per bushel at bin sites, 10 Iowa counties, accounting year July 1, 1951-June 30, 1952

District and county number	Corn stored--average monthly inventory	Costs chargeable to bin-site storage program			Annual storage cost per bushel
		County	State and district	Total	
	Bushels	*Dollars*	*Dollars*	*Dollars*	*Cents*
6	3,658,023	165,232	9,525	174,757	4.78
2	2,191,465	114,631	8,651	123,282	5.63
5	2,005,957	72,101	3,635	75,736	3.78
1	1,964,949	98,996	8,431	107,427	5.47
3	1,313,814	42,816	3,345	46,161	3.51
9	967,658	57,464	6,018	63,482	6.56
4	845,496	31,812	3,903	35,715	4.22
7	797,604	41,006	3,404	44,410	5.57
8	247,612	32,383	2,641	35,024	14.14
10	190,497	13,892	1,934	15,826	8.31
Sample average	1,418,307	67,033	5,149	72,182	[1] 5.09

[1] Weighted by the average monthly inventory.

Insurance on Bins and Grain Stocks

An annual premium was computed for fire and comprehensive insurance on the storage structures and stocks. The rate used was $3.50 per $1,000 on the depreciated value of the structures and the inventory value of the grain. This rate was the same as insurance on farm storage structures and contents. It also is representative of that paid by elevator operators on similar structures. The value of the grain was obtained by assuming a valuation of $1.50 per bushel on the average monthly inventory of corn stored during the period under study.

Property Tax on Grain Stocks

The annual property tax on grain stocks (inventory) was figured at the same rate as the grain tax to farmers in Iowa--25 cents per 1,000 bushels of grain.

Property Tax on Bins

The farm tax rate of $45 per $1,000 of assessed valuation in Story County, Iowa, was used to compute the annual property tax on the bins. The assessed valuation was assumed to be 40 percent of the original cost of the bins which is quite typical of farm structures. Since most bin sites are rented and the rent was included in the computation of storage costs, no property tax was computed on the land on which the bins are placed.

Other Taxes

The cost of items which would be subject to the Iowa sales tax by any other than a Government agency was obtained and the 2 percent sales tax computed on that amount. These items are shown in the annual audit reports for the counties under the heading of supplies, repairs, telephone and general office expense, and other expenses. The State and Federal taxes normally paid on gasoline were applied to the cost of the gasoline used for storage operations in each county.

TABLE 14.--Adjustments in total storage costs at bin sites

		County number--									
		1	2	3	4	5	6	7	8	9	10
1.	Total cost of bins........ dollars..	599,600	537,178	262,668	238,140	464,248	929,423	263,611	256,294	219,165	64,471
2.	Depreciated value of bins. dollars..	544,608	483,184	234,111	207,327	399,941	835,317	233,913	234,660	174,965	56,141
3.	Average inventory....1,000 bushels..	1,964.9	2,191.5	1,313.8	845.5	2,006.0	3,658.0	797.6	247.6	967.7	190.5
4.	Inventory value......1,000 dollars..	2,947.4	3,286.2	1,970.7	1,268.2	3,008.8	5,487.0	1,196.4	371.4	1,451.5	285.7
5.	Gasoline cost............. dollars..	1,845	1,526	149	475	168	533	123	159	219	232
6.	Taxable expenditures...... dollars..	27,282	44,873	9,833	5,552	10,824	51,403	4,911	2,485	16,737	1,673
7.	Insurance on bins (line 2 x .0035)........ dollars..	1,906	1,691	819	726	1,400	2,924	819	821	612	196
8.	Insurance on stocks (line 4 x .0035)........ dollars..	10,316	11,502	6,898	4,439	10,531	19,204	4,187	1,300	5,080	1,000
9.	Tax on stocks (line 3 x .00025)....... dollars..	491	548	328	211	501	915	199	62	242	48
10.	Tax on bins (line 1 x .018)......... dollars..	10,792	9,669	4,728	4,287	8,356	16,730	4,745	4,613	3,945	1,160
11.	Sales tax (line 6 x .02).......... dollars..	546	897	197	111	216	1,028	98	50	335	33
12.	Gas tax (line 5 x .03).... dollars..	554	458	48	143	50	160	37	48	66	70
13.	Total added cost (lines 7, 8, 9, 10, 11, and 12)................. dollars..	24,605	24,765	13,018	9,917	21,054	40,961	10,085	6,894	10,280	2,507
14.	"Incurred" cost (from table 13)...............dollars..	107.427	123,282	46,161	35,715	75,736	174,757	44,410	35,024	63,482	15,826
15.	Adjusted total cost (line 13 ≠ line 14)......dollars..	132.032	148,047	59,179	45,632	96,790	215,718	54,495	41,918	73,762	18,333
16.	Adjustment for insurance and taxes (line 13 ÷ line 14)..... percent..	23.0	20.1	28.2	27.8	27.8	23.4	22.7	19.7	16.2	15.8

Summary of Adjusted Total Costs

The costs computed for insurance and taxes were added to the recorded storage cost for each of the 10 counties to obtain an adjusted total cost in each case, as shown in table 14. As is indicated in line 16 of this table, the magnitude of this adjustment was not uniform in all 10 of the sample counties but varied from a 15.8 percent increase in total storage cost in county 10, to a 28.2 percent increase in county 3. The average percentage adjustment for the 10 counties was 22.7 percent. However, the total adjusted storage costs in table 14 were converted to annual storage costs per bushel of storage and compared with the "unadjusted" bin site costs for each county. It was thus determined that the addition of taxes and insurance had increased costs an average of 1.16 cents annually for each bushel of corn stored at bin sites. As shown in table 15, this increase is quite consistent for all counties except county 8 where per unit storage costs were exceptionally high.

TABLE 15.--Annual increase per bushel in storage costs at bin sites after adjusting costs to include taxes and insurance

District and county number	Annual storage costs per bushel		
	Unadjusted	Adjusted for taxes and insurance	Increase
	Cents	*Cents*	*Cents*
6	4.78	5.90	1.12
2	5.63	6.76	1.13
5	3.78	4.83	1.05
1	5.47	6.72	1.25
3	3.51	4.50	.99
9	6.56	7.62	1.06
4	4.22	5.40	1.18
7	6.57	6.83	.26
8	14.14	16.93	2.79
10	8.31	9.62	1.31
Sample average	[1] 5.09	6.25	1.16

[1] Weighted by the average monthly inventory.

Factors Which Affect Bin Site Storage Costs

What were the factors which caused the variations in annual per bushel cost of storage in the case of bin sites? Type of construction could not be responsible, because similar types of bins were in use in all the counties. Other factors which apparently did have an influence on bin site costs were: average monthly inventory of corn held in storage, unused capacity, and the quantities of corn which were handled at the sites during the year. The variation in these factors is shown in table 16, with counties listed according to size of inventory.

It is logical to expect that as the size of the storage operation in a county increases, total storage costs per bushel should decrease. This fact was borne out in the 10 counties studied. For example, the adjusted cost per bushel for the 5 counties where the monthly inventory was over a million bushels averaged 5.74 cents; whereas, for those counties where the average storage stocks was below a million bushels, the adjusted average cost amounted to 9.28 cents per bushel (see table 15, third column). This relationship was examined statistically as reported on pages 31-34.

TABLE 16.--Capacity, average monthly inventory, unused capacity, and quantity of corn placed in bins and removed from bins, 10 Iowa counties accounting year July 1, 1951--June 30, 1952

District and county number	Number of bin sites	Total capacity	Average monthly inventory	Unused capacity	Quantity placed in bins	Quantity removed from bins
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
6	19	4,391,289	3,658,023	733,266	623,071	162,467
2	10	2,688,421	2,191,465	496,956	531,087	704,728
5	13	2,218,910	2,005,957	212,953	78,842	273,455
1	18	2,888,725	1,964,949	923,776	207,547	544,154
3	15	1,521,341	1,313,814	207,527	208,992	102,825
9	6	1,132,206	967,658	164,546	85,404	301,362
4	10	1,251,188	845,496	405,692	112,245	128,812
7	7	1,209,492	797,604	411,888	93,975	301,975
8	7	1,226,856	247,612	979,244	55,885	251,641
10	2	273,336	190,497	82,839	5,127	123,753
Sample average	10	1,880,176	1,418,307	461,869	200,217	289,517

One would also expect storage costs per bushel to be higher in counties where the unused bin-site capacity was high because of fixed costs involved. This relationship is also illustrated in the adjusted storage costs shown in table 17. This is more apparent at the extremes than in the middle range, since most of the counties had from 66 to 86 percent of storage space in use. In county 8 where only 20 percent of capacity was utilized, the annual cost of storage was 2 or 3 times as large as that for the other counties. This relationship was also examined and is reported on page 35.

TABLE 17.--Adjusted annual storage costs per bushel by percentage of capacity in use

District and county number	Percentage of storage capacity in use	Adjusted annual storage costs per bushel
	Percent	*Cents*
5	90.4	4.83
3	86.4	4.50
9	85.5	7.62
6	83.3	5.90
2	81.5	6.76
10	69.7	9.62
1	68.0	6.72
4	67.6	5.40
7	65.9	6.83
8	20.2	16.93
Sample average	75.4	6.25

The bushels of corn put into and taken out of bin sites during any year also may be expected to influence total annual storage costs. Since additional costs are incurred to handle the corn, large amounts of movement into or out of storage should increase storage costs. The relationship in the 10 counties is apparent in table 18, which gives the percentage of storage turnover, i.e., the percentage of the average inventory

moved into and out of storage during the year. It is apparent from this table that the per bushel storage cost increased as the percentage of storage turnover increased. The results of statistical examination of this relationship are reported on page 35.

TABLE 18.--Relationship between storage turnover and adjusted annual storage costs per bushel

District and county number	Percentage of storage turnover	Adjusted annual storage costs per bushel
	Percent	*Cents*
5	9	4.83
6	11	5.90
3	12	4.50
4	14	5.40
1	19	6.72
9	20	7.62
7	25	6.83
2	28	6.76
10	34	9.62
8	62	16.93
Sample average	17.3	6.25

Changes in Costs Associated With Storage Inventory, Capacity, and Turnover

In order to measure how much each factor affects total annual storage costs at the bin sites in the 10 counties studied, multiple regression analysis was applied to the cost and volume figures. Total annual storage cost was set up in a functional relationship determined by a combination of average storage inventory, bushels of unused capacity, bushels of grain put into bins, and bushels of grain taken out of bins.

Data used in the multiple regression analysis are shown in table 19. The last 4 columns show the 4 measures of volume which affect total storage cost at bin sites and are directly comparable to the 4 similar columns for country elevators shown in table 5. The unadjusted total cost varied from $174,757 for county number 6, to $15,826 for county number 10, and averaged $72,182 for the 10 counties. The adjusted total annual storage cost varied from $215,718 for county number 6, to $18,333 for county number 10, and averaged $88,591 for the 10 counties.

Multiple regression techniques were used to measure the relationship between each of the 4 measures of volume shown in table 19 and unadjusted annual storage costs in the 10 sample counties. Also, since the adjustments in total storage costs did not affect each county uniformly, a separate regression equation was determined for the adjusted storage costs.[21] The equation for unadjusted storage cost, equation (7) $\hat{Y} = .577X_1^{.8} + .016X_2 + .076X_3 + .015X_4$ explained about 99 percent of the variation in total annual storage cost among the 10 sample counties, while the equation for the adjusted storage costs in the 10 sample counties, equation (8) $\hat{Y} = .755X_1^{.8} + .021X_2 + .085X_3 + .011X_4$, also explained about 99 percent of the variation found.

The scatter diagram shown in figure 9 illustrates that the regression equations explain most of the variation. In this figure, total annual storage cost has been plotted on

[21] The model used was the same as for the country elevators. See page 16 and appendix, p. 51.

TABLE 19.—Storage costs and volumes at bin sites

District and county	Total cost		Average monthly inventory	Unused capacity	Grain put into bin	Grain taken out of bin
	Unadjusted	Adjusted				
	Dollars	*Dollars*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1...............	$107,427	$132,032	1,964,949	923,776	207,547	544,154
2...............	123,282	148,047	2,191,465	496,956	531,087	704,728
3...............	46,161	59,179	1,313,814	207,527	208,992	102,825
4...............	35,715	45,632	845,496	405,692	112,245	128,812
5...............	75,736	96,790	2,005,957	212,953	78,842	273,455
6...............	174,757	215,718	3,658,023	733,266	623,071	162,467
7...............	44,410	54,495	797,604	411,888	93,975	301,975
8...............	35,024	41,918	247,612	979,244	55,885	251,641
9...............	63,482	73,762	967,658	164,548	85,404	301,362
10..............	15,826	18,333	190,497	82,839	5,127	123,753
Sample average...	72,182	88,591	1,418,307	461,869	200,217	289,517

the vertical axis against the bushels of average monthly storage inventory on the horizontal axis. The lower curve represents the unadjusted storage costs and the upper one the adjusted storage costs at bin sites. Any point on these two curves gives the estimated total annual storage cost associated with a particular volume of average storage inventory. The curves are based on conditions of full capacity utilization and no movement into and out of storage. The 2 sets of 10 points plotted in figure 9 represent the actual and adjusted storage cost for each of the 10 counties. The costs have been adjusted for variations in the amount of unused capacity and bushels placed into and out of storage. If the equations had explained 100 percent of the variation in storage costs, all of the dots would fall on the 2 curves.

The information shown in figure 9 has been converted into annual storage costs, per bushel, as shown in figure 10. The curves in figure 10 show the estimated annual storage costs per bushel in counties operating bin sites at different volumes of grain storage.

Costs Decrease in Relation to Increase in Size of Storage Operation

As in the case of the elevator storage costs, the estimated bin site storage costs were examined to determine the relationship between each of the measures of volume and annual storage cost per bushel. The following tables and figures show these relationships. Data were computed from regression equations (7) and (8), therefore, estimated costs given in the tables fall on the curves shown on the related figures.

In table 20 the total annual storage capacity by counties is shown in the first column, and 3 degrees of capacity utilization are shown across the top. Both unadjusted bin site costs and adjusted bin site costs are shown for each degree of utilization. All figures in this table are based on an average length of storage of 2 years.[22]

[22] In the adjusted costs, computation was made from regression equation (8), $\hat{Y} = .755X_1^{.8} + .021X_2 + .085X_3 + .011X_4$ by substituting storage capacity (X) multiplied by the appropriate constants for X_1, X_2, X_3, X_4. For example, at 75-percent capacity utilization, the equation used was $\hat{Y} = (.755)(.75X)^{.8} + (.021)(.25X) + (.085)\left(\frac{.75X}{2}\right) + (.011)\left(\frac{.75X}{2}\right)$. The per bushel cost was then computed by dividing the total cost by average storage inventory, i. e. $\frac{\hat{Y}}{.75X}$. The computation for the unadjusted costs was made from regression (7), $\hat{Y} = .577X_1^{.8} + .016X_2 + .076X_3 + .015X_4$ in a similar fashion. See appendix p. 58.

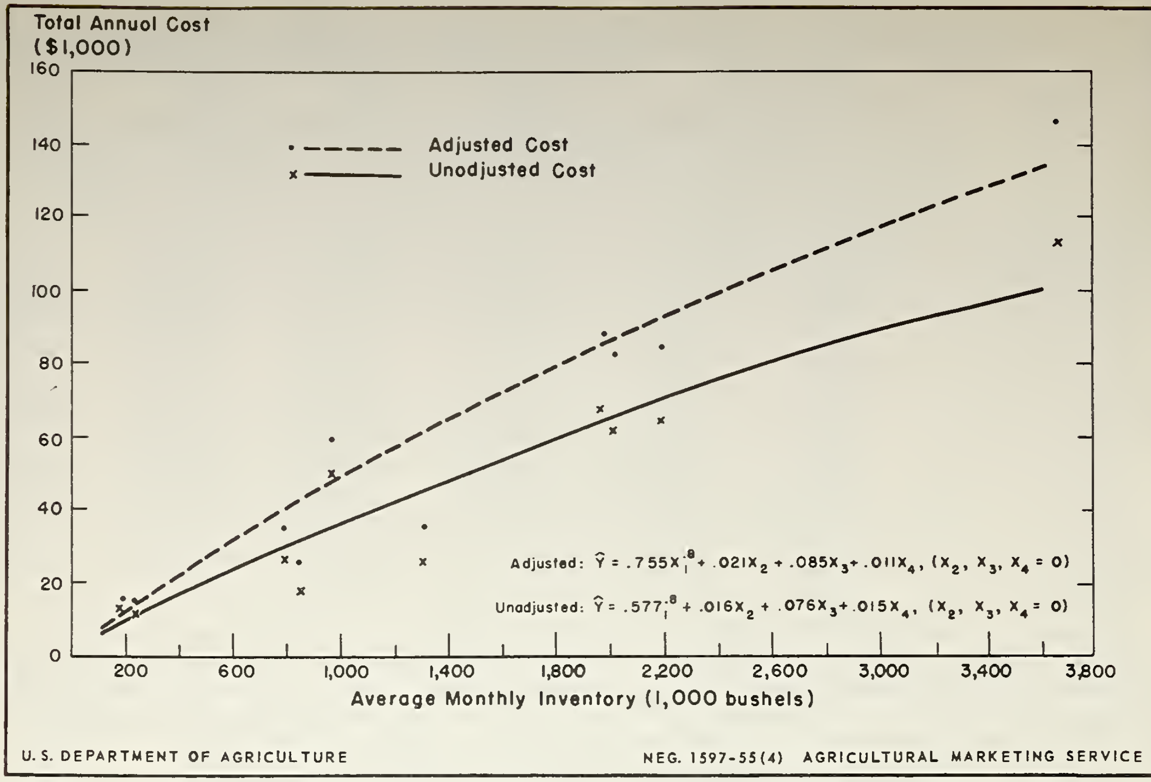

Figure 9. --Relationship between total annual storage cost and average monthly inventory, in bin sites, showing the scatter about the line of relationship, after correcting for the effect of other independent variables (X_2, X_3, X_4, in appendix), assuming full utilization of capacity.

TABLE 20.—Annual storage costs per bushel for bin sites of selected capacities utilized at 100; 75; and 50-percent of capacity (average length of storage, 2 years)

Storage capacity	Annual storage costs per bushel					
	100-percent utilization		75-percent utilization		50-percent utilization	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
400,000 bushels...	8.95	10.52	9.75	11.55	11.21	13.43
450,000 bushels...	8.85	10.39	9.65	11.41	11.09	13.28
500,000 bushels...	8.76	10.27	9.55	11.28	10.99	13.14
550,000 bushels...	8.68	10.17	9.47	11.17	10.90	13.03
600,000 bushels...	8,61	10.08	9.39	11.07	10.82	12.91
1,000,000 bushels.	8.22	9.56	8.97	10.53	10.37	12.33
1,200,000 bushels.	8.09	9.39	8.83	10.35	10.22	12.13
1,400,000 bushels.	7.98	9.25	8.72	10.20	10.10	11.97
1,600,000 bushels.	7.89	9.14	8.63	10.10	10.00	11.84
1,800,000 bushels.	7.82	9.04	8.54	9.97	9.91	11.72
2,000,000 bushels.	7.75	8.95	8.47	9.88	9.83	11.62
2,200,000 bushels.	7.69	8.87	8.41	9.80	9.76	11.53
2,400,000 bushels.	7.64	8.80	8.35	9.72	9.70	11.45
2,600,000 bushels.	7.59	8.73	8.30	9.65	9.64	11.35
3,000,000 bushels.	7.50	8.62	8.21	9.54	9.55	11.25

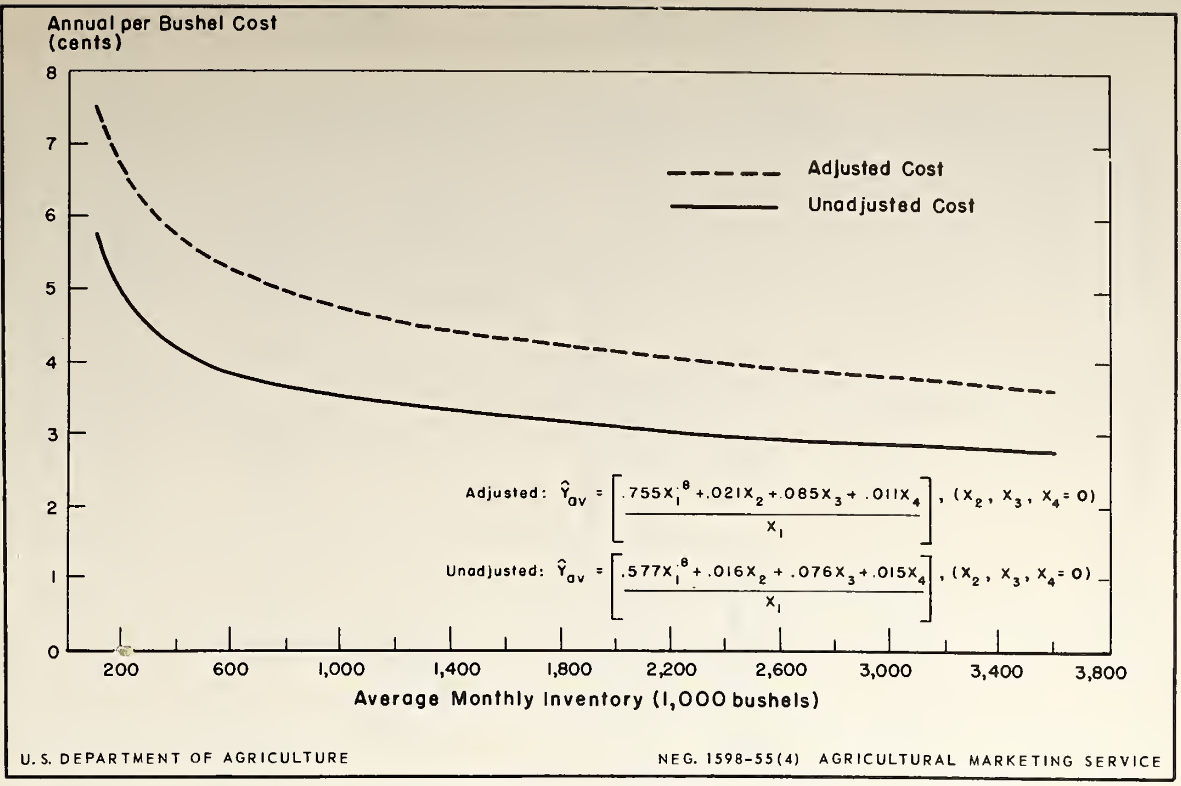

Figure 10. --Relationship between annual storage cost per bushel and average monthly inventory, in bin sites, after effect of other independent variables (X_2, X_3, X_4, in appendix) is removed, assuming full utilization of capacity.

The estimated annual cost per bushel for storage at bin sites decreases as the size of the storage operation increases. This is true for both the unadjusted and the adjusted bin site costs. At 100-percent utilization of storage capacity the adjusted annual storage costs per bushel decrease from 10.52 cents at 400,000 bushels to 9.56 cents at 1,000,000 bushels, to 8.62 cents at 3,000,000 bushels of grain stored for the year. The same general relationship is also apparent for both the unadjusted and the adjusted bin site storage costs at 75 percent and 50 percent utilization of capacity.

Figure 11 shows the information in table 20 in graphic form. Estimated annual storage costs per bushel have been plotted on the vertical axis against storage capacity on the horizontal axis. These curves show the relationship between bin site storage capacity and total storage costs per bushel at the three different degrees of utilization of storage capacity. They show that storage costs decline most rapidly at the smaller volumes and remain relatively stable at bin sites of large volumes.

The curves in figure 11 differ from those in figure 10 in that those in 11 consider an amount of corn moved into and out of the bin sites equal to half of the average inventory, while the curves in 10 consider no corn was moved into or out of storage during the year.

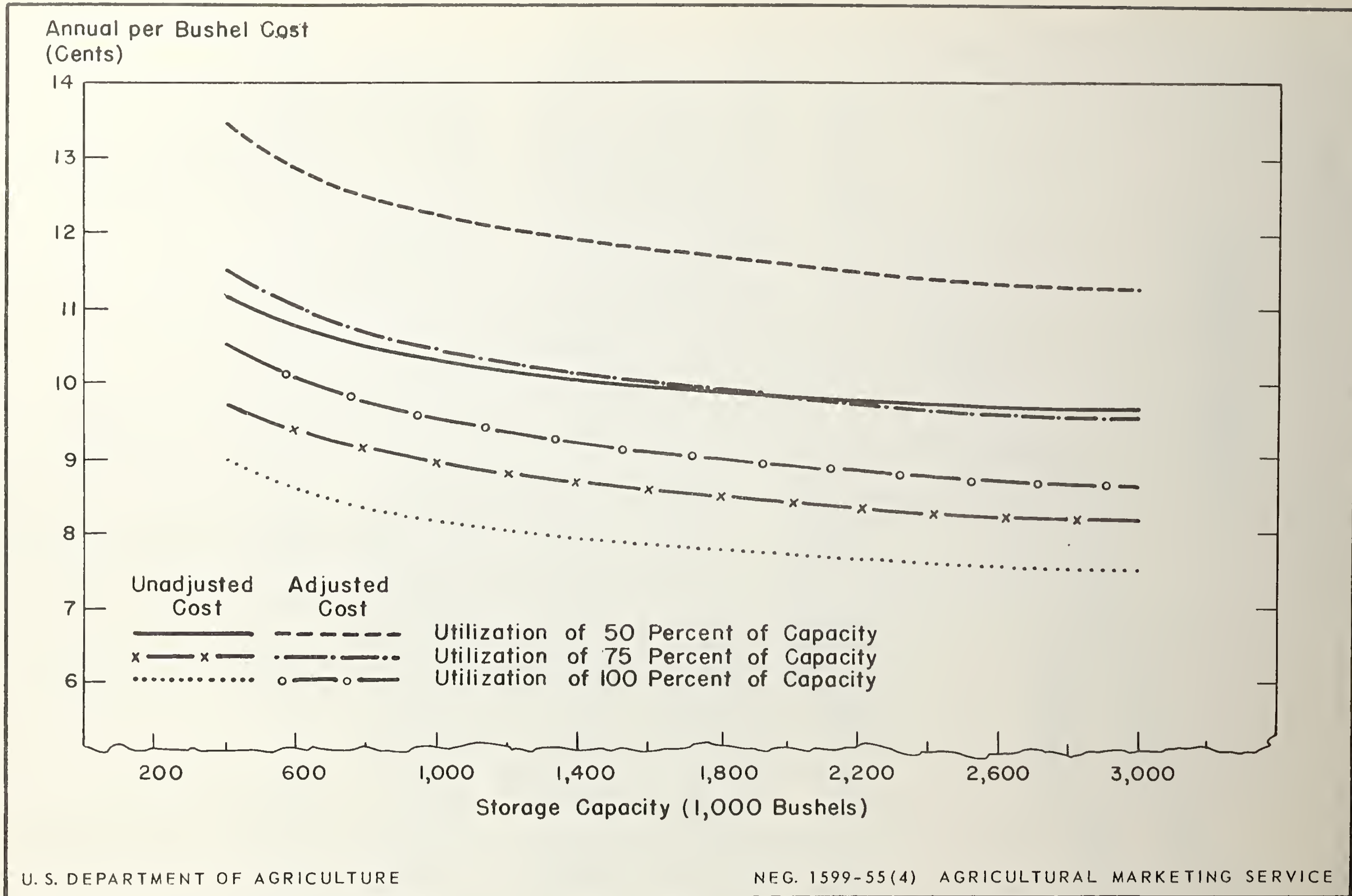

Figure 11. --Relationship between annual storage cost per bushel and storage capacity in bin sites. Average length of storage, 2 years.

Bin Site Costs Increase as Degree of Utilization Decreases

Table 21 shows clearly the inverse relationship between the estimated annual storage costs per bushel in bin sites and the degree of utilization of storage capacity. The average storage period considered is 2 years, and 5 different capacities are considered. As before, both the unadjusted and the adjusted cost figures are shown for each capacity at each degree of utilization. At a storage capacity of 1,500,000 bushels, the adjusted annual storage costs change from 9.19 cents per bushel at 100-percent utilization, to 9.91 cents per bushel at 80-percent utilization, to 11.90 cents per bushel at 50-percent utilization.[23] The same general relationship exists for both the adjusted and unadjusted cost figures at other capacities.

The relationship shown in table 21 is shown graphically in figure 12. Estimated annual storage costs per bushel have been plotted on the vertical axis against the degree of utilization of capacity on the horizontal axis. While there is a decided decline in costs over the entire range, the decline is most rapid at the lower degrees of capacity utilization.

Bin Site Costs Decrease as Storage Period Increases

Table 22 shows the relationship between the computed length of storage and the estimated storage cost per bushel at bin sites. This table is based on an average of 90-percent utilization of capacity and considered the same capacity volumes as were considered in table 21. Because of the high costs of placing corn into and taking it out of bin site storage, the average length of storage shows an even more marked effect on annual bin site storage costs per bushel than on annual storage costs per bushel in elevators. This is true for both the unadjusted and the adjusted storage costs. For example, at 1,500,000 bushels capacity the adjusted bin site storage cost decreases from 23.91 cents for 6 months' length of storage to 5.67 cents for 10 years.[24] A similar relationship exists for both the unadjusted and the adjusted bin site storage costs at other storage capacities.

In interpreting table 22, it must be remembered that the average length of storage indicated in the first column refers simply to the relationship between the volume of grain moved into and out of storage during the year and the average monthly inventory. It does not deal with the actual length of time the grain is stored. All cost figures in table 22 are for 1 year and would have to be multiplied by the number of years desired to find out what the total per bushel storage cost would be for any period other than 1 year.

In figure 13, the adjusted costs shown in table 22 have been plotted on the vertical axis against the average length of storage on the horizontal axis. These curves show that storage costs decrease substantially as the average length of storage increases. The rate of decrease is much more pronounced in the shorter storage periods.

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[23] These computations were made from regression equations (7) and (8) in the same manner as the figures reported for elevators in table 11 and figure 6. See footnote page 18 and appendix p. 55.

[24] These computations were made from regression equations (7) and (8) in the same manner as the figures reported for elevators in table 12 and figure 7. See footnote page 21 and appendix p. 56.

TABLE 21.--Annual storage cost per bushel in bin sites with capacity utilized in various degrees (average length of storage, 2 years)

Degree of utilization	Annual storage costs per bushel									
	400,000 bushels		800,000 bushels		1,500,000 bushels		2,000,000 bushels		2,500,000 bushels	
	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
100 percent.........	8.95	10.52	8.39	9.78	7.94	9.19	7.75	8.95	7.60	8.77
90 percent.........	9.22	10.87	8.65	10.12	8.19	9.51	8.00	9.26	7.85	9.08
80 percent.........	9.55	11.30	8.96	10.52	8.49	9.91	8.30	9.65	8.15	9.46
70 percent.........	9.97	11.83	9.35	11.02	8.87	10.40	8.67	10.14	8.52	9.94
60 percent.........	10.50	12.51	9.87	11.30	9.37	11.04	9.16	10.77	9.01	10.57
50 percent.........	11.21	13.43	10.56	12.58	10.05	11.90	9.83	11.62	9.67	11.41

TABLE 22.--Annual storage cost per bushel for bin sites of selected capacities, by average length of storage (90-percent utilization of capacity)

Average length of storage	Annual storage cost per bushel									
	400,000 bushels		800,000 bushels		1,500,000 bushels		2,000,000 bushels		2,500,000 bushels	
	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted	Unad-justed	Adjusted
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
6 months..........	23.96	25.27	22.38	24.52	21.92	23.91	21.72	23.66	21.58	23.48
12 months..........	13.80	15.67	13.23	14.92	12.76	14.32	12.57	14.06	12.43	13.88
18 months..........	10.75	12.47	10.17	11.72	9.71	11.11	9.51	10.86	9.12	10.68
24 months..........	9.22	10.87	8.65	10.12	8.19	9.51	8.00	9.26	7.85	9.08
30 months..........	8.31	9.91	7.63	9.05	7.27	8.55	7.07	8.30	6.93	8.12
36 months..........	7.70	9.27	7.12	8.52	6.66	7.91	6.46	7.66	6.32	7.48
42 months..........	7.26	8.81	6.68	8.06	6.22	7.46	6.03	7.21	5.89	7.02
48 months..........	6.94	8.47	6.36	7.72	5.90	7.11	5.70	6.86	5.56	6.68
60 months..........	6.48	7.99	5.64	7.23	5.44	6.63	5.25	6.38	5.10	6.20
72 months..........	6.17	7.67	5.59	6.91	5.13	6.31	4.94	6.06	4.80	5.88
84 months..........	5.95	7.44	5.17	6.69	4.92	6.08	4.72	5.84	4.58	5.65
120 months.........	5.56	7.03	4.98	6.27	4.52	5.67	4.33	5.42	4.19	5.24

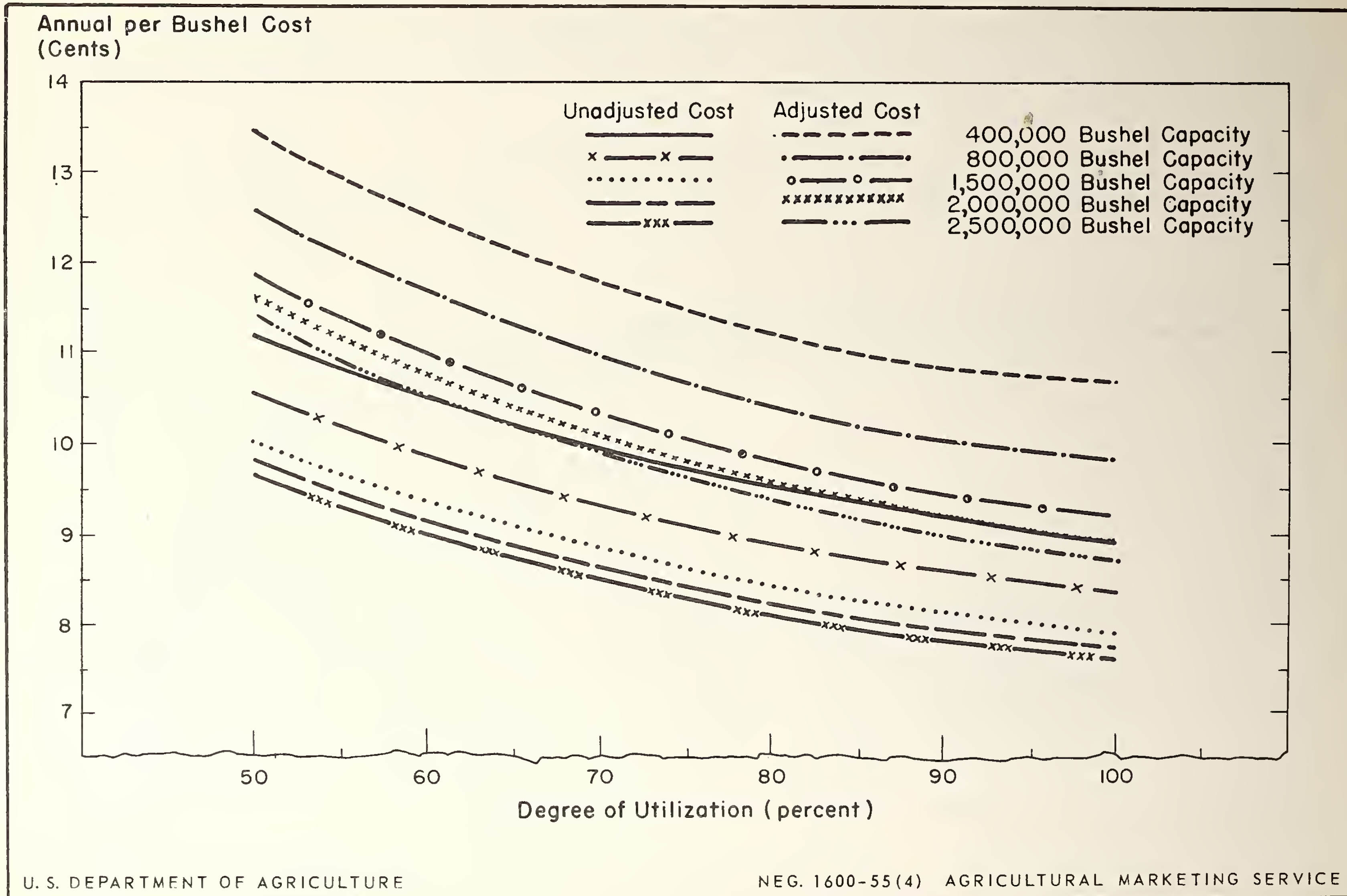

Figure 12. --Relationship between annual cost per bushel and degree of utilization of storage space in bin sites. Length of storage, 2 years.

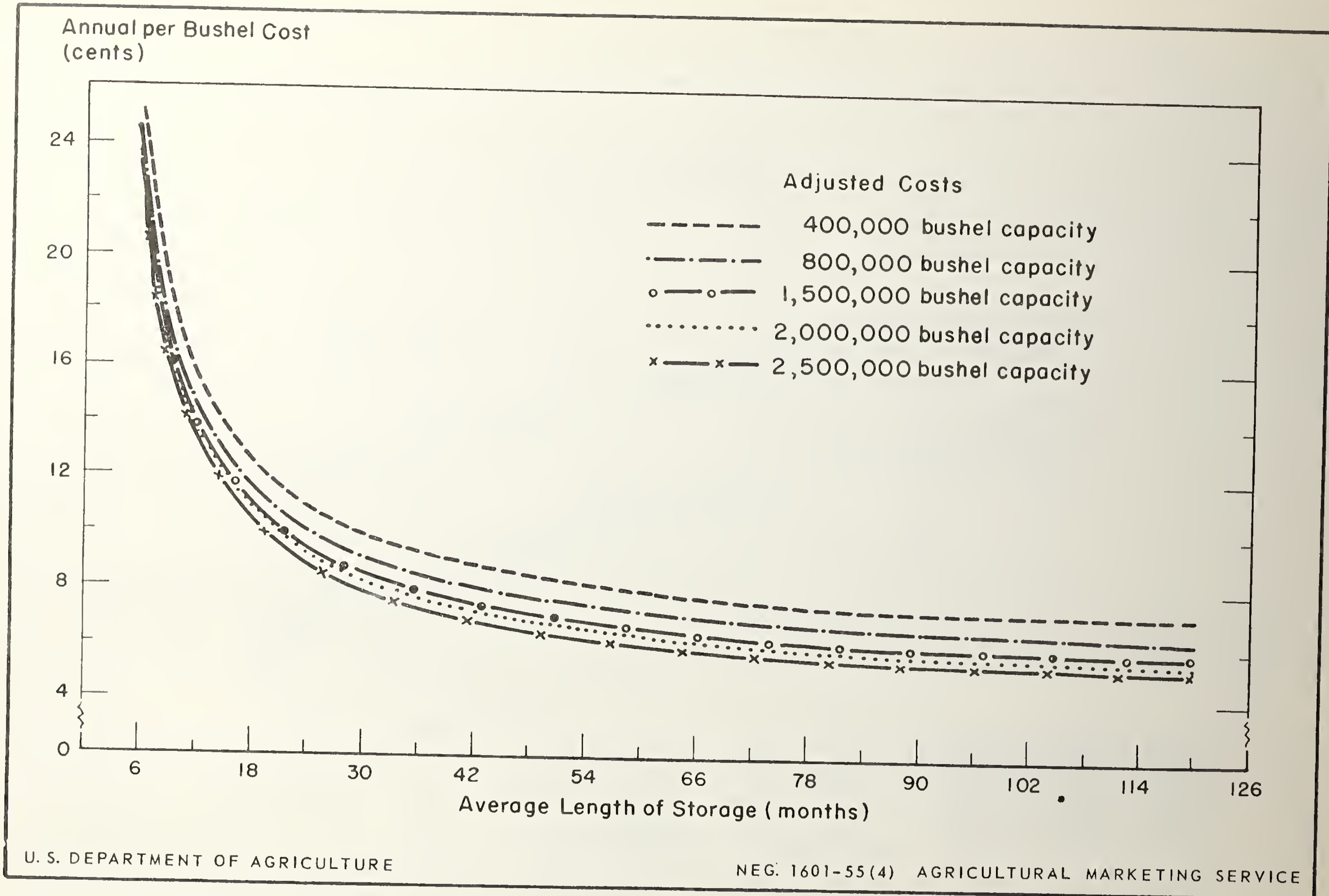

Figure 13 --Relationship between annual cost per bushel and average length of storage in bin sites, with 90 percent of capacity utilized.

STORAGE COSTS IN FARM STRUCTURES

Most of the new crop of corn in Iowa each fall is put in farm storage structures. The greater part of it is stored in ear-corn cribs of wood slat construction where drying takes place naturally during the spring and early summer months following harvest. If the corn is stored in a tight-walled crib, this natural drying must be replaced with mechanical aeration. The fact that ear corn dries out the first year to a moisture content safe for storage as shelled corn is important from the standpoint of a long-term storage program.

The farm storage costs considered in this report, as in the case of elevator and bin site storage, are those beginning with the CCC take-over date, or the second year of storage.[25] However, in contrast to the elevator and bin site studies, farm costs are not based on an empirical study of actual storage expenditures. Instead, they have been determined by a budgeting procedure based on engineering estimates and costs of inputs to farmers in central Iowa. There were several reasons for the difference in procedure. An important factor was the limitation on time and resources available for the study. Another reason was that only a few farms now have storage equipment adequate to maintain quality of stored corn over a period of several years. Consequently, farm storage costs based on current practices would not reflect costs comparable to long-term storage of corn in elevators and bin sites.

Historically, only a limited quantity of corn has been stored on farms for a period longer than one year. In comparison to the total storage program of CCC-owned corn, "resealing" of corn after the first year on farms had brought only limited response from producers by 1952. Therefore, the population which could have been sampled in the case of farm storage was limited.

Type and Size of Storage Units and Equipment

Two types of structures for storage of ear corn and one type for shelled corn were considered in this phase of the study. All three are permanent-type structures which are filled with corn by a portable elevator. One of the ear-corn structures was the conventional double wood corn crib, slatted to provide for natural ventilation and with a driveway between the two cribs. Such cribs have a fairly flat gable roof and provide no overhead bin storage space. Rated capacity assumes the corn will be piled as high as possible in the crib.

The other ear-corn structure was a prefabricated metal building. Such structures are becoming more popular, because they can be used for other purposes when not needed for grain. They are tight structures and depend on mechanical ventilation to dry new corn in the fall and to control moisture migration thereafter.

The shelled-corn structure studied was a round steel bin similar in design to those used at bin sites. These bins are normally built on a concrete block foundation and have a gravel floor.

Capacities of storage units used as a basis for the study were selected to represent the normal corn production of small, average, and large farms. The average corn loan in Iowa has been approximately 1,300 bushels, but a bin of this capacity is too small to meet storage space requirements for the larger farms in the State. Therefore, bins selected for study were of capacities which would provide storage space for 1,000 bushels, 2,000 bushels, and 5,000 bushels of corn (shelled corn basis). Where it was impossible to attain these exact capacities in the storage structures, they were approximated as closely as possible.

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[25] For this reason the farm storage costs are not directly applicable to storage of other than CCC-owned corn on the farm. For other purposes, modifications would need to be made in the cost determination procedure.

Wood cribs can be constructed in dimensions to provide capacities exactly as selected. All cribs had an overall width, including a driveway, of 27 feet. The 1,000-bushel crib was 12 1/2 feet long, the 2,000-bushel crib was 25 feet long, and the 5,000-bushel crib was 62 1/2 feet long. Their original cost was based on actual board feet of lumber needed without allowing for waste in cutting. The cost is therefore representative of costs that might be expected for constructing a 14-foot or 18-foot crib, or a crib of other common dimensions.

In the case of the prefabricated metal buildings used for ear-corn storage, the 5,000-bushel size, which has an area dimension 32 feet wide by 36 feet long, is most commonly used. However, structures are available commercially from several companies in the smaller sizes, and two of these were selected for study. One was 16 by 28 feet with a capacity of 1,100 bushels of ear corn. The other was 24 feet by 32 feet, and its capacity was 2,200 bushels.

Of the round steel bins for shelled corn, 1,000-bushel, 2,200-bushel, and 5,450-bushel sizes were the nearest available to the selected capacities. (The 5,450-bushel capacity was obtained by using 2 bins, 1 of 2,200-bushel and 1 of 3,250-bushel rated capacity.)

Determination of Costs

Specifications for storage structures and aeration equipment were obtained by consultation with agricultural engineers. Most of the cost information was obtained for and is based upon conditions existing in Story County, Iowa. These conditions were considered representative of those of the State as a whole.

A bill of materials was prepared covering items used for construction of the three selected sizes of the double wood crib. Local market price for the materials was obtained from lumber yards and ready-mix concrete firms and included delivery charges for a distance of 10 miles. Erection costs were based on itemized estimates from contractors who specialize in building farm cribs.

Cost of the prefabricated metal structure for ear corn was based on estimates obtained from commercial firms handling such structures. The cost included cost of materials, erection, and aeration equipment. Costs of materials and erection of the foundation were estimated by commercial contractors.

The cost of the round bins for shelled-corn storage was obtained from commercial firms handling such structures and from actual costs of such bins on CSS records. The erection cost (including foundation) for these bins was obtained from ASC accounts.

The cost of mechanical aeration sufficient to equalize atmospheric and grain mass temperatures over a storage period of several years was included in total costs for metal buildings and round bins of the 2 largest sizes. Aeration equipment was not considered essential for the 1,000-bushel bins, or for double wood cribs where the natural flow of air through the slat sides provides ventilation for the corn.

Aeration equipment for the round bins consisted of a small fractional-horsepower motor with fan attached to a perforated pipe extending down into the grain mass. This fan draws air from the interior of the grain mass and exhausts it out the top of the bin. In the case of the metal building for ear-corn storage, costs included aeration equipment capable of moving sufficient air through the bins to ventilate the corn. This included, in addition to tunnels built in the bins, a fan equipped with a 3-horsepower motor for the 2,200-bushel building, and a 5-horsepower motor for the 5,000-bushel structure. Since ear corn stored in the metal buildings would have been dried during the first year of storage, the fans would operate only to give ventilation during the second year, and costs were computed according to operating schedules recommended by agricultural engineers.

The fixed costs considered in the budgeting of farm storage costs were:

Depreciation

The annual depreciation rate used was 3 percent for the wood cribs and 5 percent for the other 2 structures. All aeration equipment was depreciated at the rate of 10 percent per year.

Interest

Interest was charged at the rate of 5 percent per year on the fixed investment in the case of all 3 types of structures. However, the annual depreciation for three years was subtracted from the original cost to provide a base of depreciated fixed investment before the 5-percent annual charge was computed.

Insurance

The rate for fire and comprehensive insurance for the three types of farm storage structures was obtained from a mutual insurance association. The annual rate used was $3.50 per $1,000 valuation.

Property Tax

The property tax rate for farm grain storage structures in rural consolidated school districts for Story County, Iowa, was used in the study. This rate was $45 per $1,000 of the assessed valuation of 60 percent of the market value. This assessed valuation would be 75 cents per square foot (or 8 cents per cubic foot) for wood cribs and metal structures used for ear-corn storage and about $200 for a 1,000-bushel round bin used for shelled corn with $75 for each additional 1,000 bushels of capacity.

The major variable costs were:

Repairs

Annual repair costs were computed from the list of repairs necessary over the life of the structure as estimated by the agricultural engineers and the local market prices for such items. The repair items included for the wood cribs over 33-1/3 years estimated life were replacement of the lower 3 feet of cribbing, 1 set of new doors, 1 new roof, 5 single coats of paint for the crib, and 2 single coats of paint for the steel roof. The only repair item included for the steel bins and prefabricated metal structures for ear corn for a 20-year estimated life was 2 single coats of paint. An annual repair cost for aeration equipment was computed at the rate of 3 percent of the original cost of such equipment.

Pest Control

The annual cost of rodent control, fumigation, and residual insecticides was based on recommendations by entomologists and on local market prices for the recommended bait, fumigant and insecticide. Labor cost associated with the pest control is included in the total labor cost.

Insurance and Tax on Grain Stocks

For purposes of computing the annual insurance premium on the grain stocks, corn was valued at $1.50 per bushel, and the annual rate used was $3.50 per $1,000 valuation. The Iowa grain tax rate of 25 cents per 1,000 bushels of grain held on farms beyond 1 year was used.

Labor

The total hours of labor for supervising and caring for the shelled corn in farm bins, including fumigation, was estimated at 1 hour per week for 1,000 bushels, 1 1/2 hours per week for 2,000 bushels and 2 hours per week for 5,000 bushels. The estimated hours of labor in the case of ear corn (in both wood and metal buildings) was half of these amounts. In all cases, the wage rate used was $2 per hour.

Electricity

The electricity cost for those structures requiring aeration was based on the average cost to farmers in Story County of 2.6 cents per kilowatt hour. Hours of operation used at full storage capacity were 222 hours for the 2,200-bushel and 370 hours for the 5,000-bushel steel ear-corn structures, and 130 hours for the 2,200-bushel and 245 hours for the 5,450-bushel round bins. In determining electricity cost the full load electricity consumption rate for the various motors was used as the kilowatt hours per hour of operation.

Handling Charge

As long as ear corn remains in the crib in which it was placed following harvest, there is no cost chargeable to handling. Therefore, no grain handling charge was included in the cost analysis for ear-corn storage. However, if corn has been shelled, placed in a round bin, and later delivered to a bin site or elevator, moving the corn in and out of the shelled-corn bin represents extra handling. This extra handling is chargeable to the long-term storage operation. This cost was figured at 1 cent per bushel.

Total storage costs were determined by budgeting procedure for different sizes and types of storage structures at 3 rates of utilization--100-, 75- and 50-percent of bin capacity. Table 23 presents computed annual total costs of storage, as well as fixed and variable costs, for each structure studied.

Fixed costs, which are incurred irrespective of the degree of utilization of the bins, were held constant for all 3 utilization rates in the wood cribs and the round steel bins. However, because of the suitability of the metal, prefabricated ear-corn structures for uses other than storage, 87 1/2 percent of the total fixed cost was charged to the stored grain at 75-percent utilization, and 75 percent was charged at 50-percent utilization in those structures.

The total variable cost was computed for each type of structure at the 3 capacities and at the 3 rates of utilization. Some of the variable cost items, such as tax and insurance on grain stocks, vary proportionately with the volume of corn stored. Other items, while varying with the volume stored, do not vary proportionately. The cost of residual insecticides, fumigation, and rat control at each rate of utilization was based on the size of the structure and the number of bushels of corn stored. In the case of the annual cost of repairs to the storage structure and electricity used in ventilation, 90 percent of the cost at full utilization was charged in the case of 75 percent utilization, and 80 percent of this figure was charged in the case of 50-percent utilization. Eighty-seven and a half percent of the full utilization annual labor cost was charged at 75 percent utilization and 75 percent was charged at 50-percent utilization.

Factors Which Affect Farm Storage Costs

The annual storage costs per bushel in the 3 types of farm structures are shown in table 24. The type and size of storage structure is indicated across the top of the table and the degree of utilization for the fixed, variable and total storage costs is shown in the first column.

Examination of this table reveals that in general the farm storage costs are substantially higher than either the bin site or the elevator storage costs per bushel stored.

TABLE 23.--Annual fixed, variable, and total costs of storage in 3 types of farm structures

Cost item	Annual storage costs								
	Ear-corn structures[1]						Shelled-corn structures		
	Double wood crib			Prefabricated metal building			Round steel bin		
	1,000 bu.	2,000 bu.	5,000 bu.	1,100 bu.	2,200 bu.	5,000 bu.	1,000 bu.	2,200 bu.	5,450 bu.
Fixed costs:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Building depreciation.........	35.53	53.24	115.28	75.00	113.65	220.00	22.85	35.60	78.10
Equipment.....do.............	none	none	none	none	52.40	60.00	none	5.85	11.70
Insurance....................	4.61	6.90	13.65	7.00	9.80	17.50	1.80	2.70	5.90
Interest at 5%...............	53.88	80.76	159.68	82.09	114.94	208.00	21.47	32.31	70.49
Property taxes...............	6.75	13.50	33.75	9.08	13.61	23.33	5.40	7.43	15.53
Total fixed costs...........	100.77	154.40	322.36	173.17	304.40	528.83	51.52	83.89	181.72
Variable costs:									
Repairs:									
a. 100% utilization.........	9.66	14.68	25.43	18.26	18.26	22.23	3.45	5.14	8.59
b. 75%.....do.............	8.69	13.21	23.79	16.43	16.43	20.01	3.11	4.63	7.64
c. 50%.....do.............	7.73	10.94	21.14	14.61	14.61	17.78	2.76	4.11	6.79
Fumigation and rodent control.									
a. 100% utilization.........	6.50	8.50	14.50	7.50	8.90	14.50	20.50	37.40	78.30
b. 75%.....do.............	4.85	6.65	11.65	5.75	6.95	11.65	16.45	30.66	66.47
c. 50%.....do.............	3.80	4.80	9.60	4.30	5.05	9.60	12.90	22.92	54.64
Labor:									
a. 100%.....do.............	52.00	78.00	104.00	54.00	81.90	104.00	104.00	163.80	208.00
b. 75%.....do.............	45.50	68.25	91.00	47.25	71.66	91.00	91.00	143.32	182.00
c. 50%.....do.............	39.00	58.50	78.00	40.50	61.43	78.00	78.00	122.86	156.00
Insurance and tax on grain stocks:									
a. 100% utilization.........	5.50	11.00	27.50	6.06	12.12	27.50	5.50	12.12	30.05
b. 75%.....do.............	4.13	8.26	20.63	4.54	9.09	20.63	4.13	9.09	22.62
c. 50%.....do.............	2.76	5.50	13.81	3.03	6.07	13.81	2.76	6.17	15.03
Electricity:									
a. 100%.....do.............	none	none	none	none	5.77	9.61	none	3.38	6.76
b. 75%.....do.............	none	none	none	none	5.19	8.65	none	3.04	6.08
c. 50%.....do.............	none	none	none	none	4.62	7.69	none	2.70	5.41
Handling:									
a. 100%.....do.............	none	none	none	none	none	none	10.00	22.00	54.40
b. 75%.....do.............	none	none	none	none	none	none	7.50	16.50	40.88
c. 50%.....do.............	none	none	none	none	none	none	5.00	11.00	27.25
Totals:									
a. 100%.....do.............	73.66	112.18	172.43	85.82	126.95	177.84	143.45	243.84	386.10
b. 75%.....do.............	63.17	96.37	147.07	73.97	109.32	151.94	122.19	207.24	325.69
c. 50%.....do.............	53.29	79.74	122.55	62.44	91.78	126.88	101.42	169.76	265.12
Total costs:									
a. 100%.....do.............	174.43	266.58	494.79	258.99	431.35	706.67	194.97	327.73	567.82
b. 75%.....do.............	163.94	250.77	469.43	225.49	375.67	614.67	173.71	291.13	507.41
c. 50%.....do.............	154.06	234.14	444.91	192.32	320.08	523.50	152.94	253.65	446.84

[1] Capacities of ear-corn structures are indicated on shelled-corn basis.

The primary reason for this is that when all costs--implicit as well as out-of-pocket--are considered, the storage volume on an individual farm is not large enough to reduce annual per bushel costs of storage to the level attained in bin site and elevator storage. (As explained later, this would not necessarily be true if only the costs actually paid out by the farmer were considered.)

TABLE 24.--Annual storage costs per bushel in 3 types of farm structures

Cost item and utilization of capacity	Annual storage costs per bushel								
	Ear-corn structures[1]						Shelled-corn structures		
	Double wood crib			Prefabricated metal building			Round steel bin		
	1,000 bu.	2,000 bu.	5,000 bu.	1,100 bu.	2,200 bu.	5,000 bu.	1,000 bu.	2,200 bu.	5,450 bu.
Fixed costs:	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
100 percent....	10.1	7.7	6.4	15.7	13.8	10.6	5.2	3.8	3.3
75 percent....	13.4	10.3	8.6	18.4	16.1	12.3	6.9	5.1	4.4
50 percent....	20.2	15.4	12.9	23.6	20.8	15.9	10.3	7.6	6.7
Variable costs:									
100 percent....	7.4	5.6	3.4	7.8	5.8	3.6	14.3	11.1	7.1
75 percent....	8.4	6.4	3.9	9.0	6.6	4.1	16.3	12.6	8.0
50 percent....	10.7	8.0	4.9	11.4	8.3	5.1	20.3	15.4	9.7
Total costs:									
100 percent....	17.5	13.3	9.8	23.5	19.6	14.2	19.5	14.9	10.4
75 percent....	21.8	16.7	12.5	27.4	22.7	16.4	23.2	17.7	12.4
50 percent....	30.9	23.4	17.8	35.0	29.1	21.0	30.6	23.0	16.4

[1] Capacities of ear-corn structures are indicated on shelled-corn basis.

At 100-percent utilization, the unit cost of farm storage is lowest in the double wood crib and highest in the prefabricated metal building at all three capacities. With one exception (the 5,000-bushel bins) this is also true when storage is utilized at 75 percent of capacity. At 50-percent utilization, storage in steel bins is less than in ear-corn structures for the 3 capacities.

Comparison of Costs by Type of Structure

One of the chief values of the prefabricated metal building for ear-corn storage is that it may be readily converted to other uses on the farm during years when not needed for grain storage. This is not adequately reflected in the comparative cost figures. Another reason for the recent popularity of this type of structure on Iowa farms is the fact that the mechanical aeration equipment used in them permits earlier harvesting and reduces field losses. Because this study was concerned only with farm storage of reserve stocks of corn which already had been stored a year on the farm, this second advantage of the prefabricated metal building for ear-corn storage also was disregarded.

The fact that the crib storage costs are somewhat lower than the costs for bin storage of shelled corn deserves special comment, particularly because bin storage has been much more popular than ear-corn storage with Iowa farmers who have "resealed" corn on their farms. The bin storage costs are higher than the crib storage costs because the lower fixed costs--depreciation, interest, insurance and taxes--for the

steel bins are more than offset by the higher variable costs--extra handling, fumigation, labor, etc.--incurred in bin storage.

When considering the two, farmers are usually more concerned with the fixed costs and in particular the original cost of the structure, which is lower for bin storage. Also, they frequently need to clear their crib space for their new crop corn and are more likely to have bin space available. Furthermore, many farmers are reluctant to leave ear corn in the crib for longer than a year. And they have some cause for this reluctance because of insect and rodent problems and because of the additional pressures on the crib with the further settling of the corn the second year.

Several other popular types of farm storage structures were not considered in this study, primarily because of the limitations of time and resources. Temporary structures such as pole and picket cribs were not considered since such structures are not comparable with bin site and elevator storage. However, many other types of permanent and semipermanent storage structures are used on Iowa farms. Examples include concrete and tile structures and wire mesh cribs, as well as many different types of wooden cribs and bins. The selection of the 3 types studied in no way indicates a preference by those concerned with the study for these structures over other types of farm storage structures on the market.

Table 25 gives a comparison, by percentages, of total annual costs per bushel for the three types of structures shown in table 24, using the unit costs of storage for wood bins as the basis for comparison.

TABLE 25.--Cost of storing corn in prefabricated metal building and round steel bin expressed as percentage of cost of storing in wood bin, by size of bin and utilization of capacity

Bin size and utilization of capacity	Type of structure		
	Double wood crib	Prefabricated metal building	Round steel bin
	Percent	*Percent*	*Percent*
Small:			
Full	100	134	111
3/4 full	100	126	106
1/2 full	100	113	99
Medium:			
Full	100	147	112
3/4 full	100	136	106
1/2 full	100	124	98
Large:			
Full	100	145	106
3/4 full	100	131	99
1/2 full	100	118	92

Comparison of Costs by Size of Structure

The total annual cost per bushel of farm storage increases rapidly with each decrease in bin size. Table 26 gives the average percentage increases in costs for the 2 smaller types of bins over the 5,000-bushel bins, as developed from data in table 24.

TABLE 26.--Cost of storing corn in medium-sized and small bins expressed as percentage of cost of storing in large bins, by type of structure

Type of structure	Bin size		
	Large	Medium	Small
	Percent	*Percent*	*Percent*
Double wood cribs	100	133	175
Prefabricated metal buildings	100	138	166
Round steel bins	100	142	187

The annual cost per bushel for storage in medium-size bins (approximately 2,000-bushel capacity) of all structural types is about 40 percent more than for the large bins (5,000 or 5,450-bushel capacity). For small bins, the unit cost of storage in 1,100-bushel prefabricated metal buildings is two-thirds more than it is for the 5,000-bushel structures. The increase for each bushel year of corn held is even greater for the other 2 types of bins--76 percent increase for wood bins and 87 percent for round steel bins.

From the standpoint of long-term farm storage, it is possible to effect economies of cost with each increase in bin size, provided the available storage space is utilized to the greatest possible degree.

The relationship between storage capacity and annual storage costs per bushel at full utilization of capacity in the 3 types of structures is shown graphically in figure 14. The annual storage cost per bushel has been plotted on the vertical axis against the storage capacity on the horizontal axis. The 3 curves represent the 3 types of structure. Each curve is derived from the estimates of storage costs at the 3 different capacities shown in table 24.

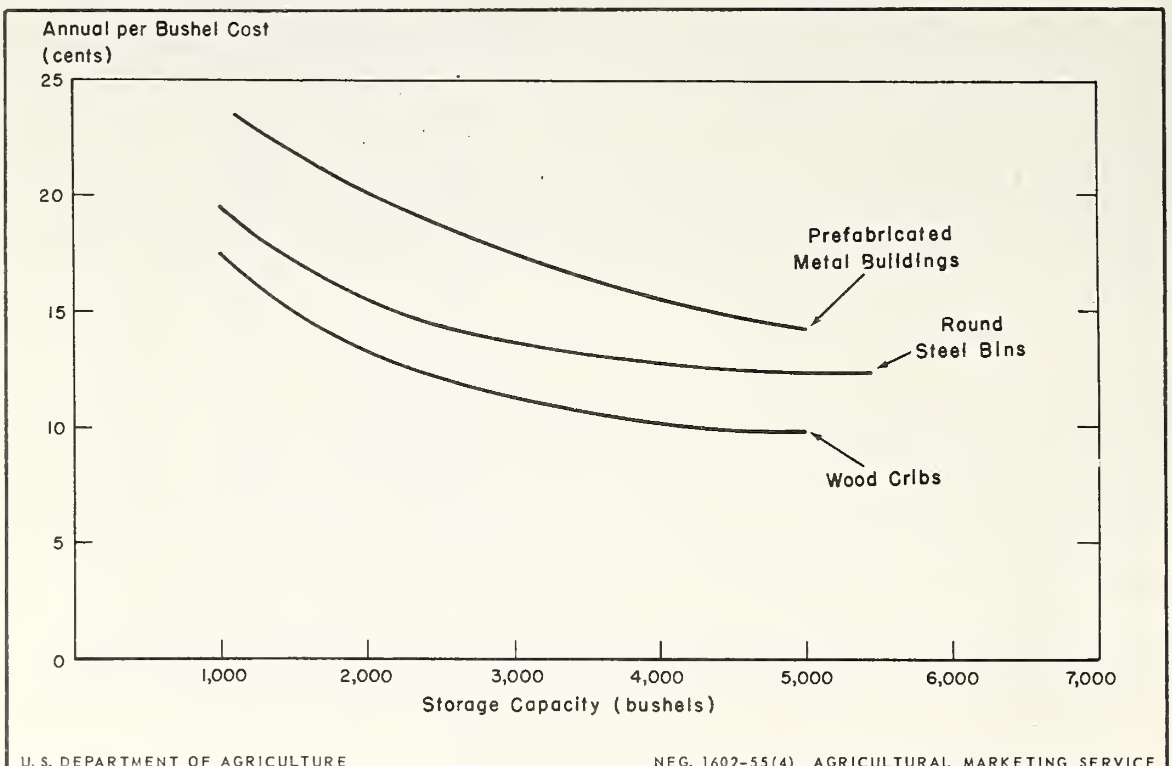

Figure 14.--Relationship between annual cost per bushel and storage capacity, for 3 types of farm storage structures, with 100 percent of capacity utilized.

While all three of these curves slope downward to the right over the range computed, they flatten out as volume of corn stored increases, indicating that greater cost economies are associated with size at smaller than at larger volumes.

The 3 curves also provide a direct comparison between storage costs in the 3 types of structures. The curve for the wood cribs is the lowest of the three over the entire storage volume range computed. Also, the curve for the wood-crib storage is the flattest and the curve for the metal structure for ear corn is the steepest, indicating that the cost economies associated with size are relatively most important in metal building storage and relatively least important in wood-crib storage.

Comparison of Costs by Rate of Capacity Utilization

The rate of utilization of capacity has a decided influence on the cost of storage at the farm level, just as it does in elevator and bin site storage. The average percent increases in costs of storage per bushel for farm bins used at 75 to 50 percent of capacity over the cost at full utilization are shown in table 27.

TABLE 27.--Cost of using 50- and 75-percent capacity for storing corn, expressed as percentage of cost of using full capacity

Type of structure	Utilization of capacity		
	100 percent	75 percent	50 percent
	Percent	*Percent*	*Percent*
Double wood crib	100	126	178
Prefabricated metal buildings	100	116	149
Round steel bins	100	119	156

Both table 24 and table 27 show the high cost of maintaining unused storage space. The annual cost per bushel stored increased by a fifth, on the average, when the bins were utilized at 75 percent of capacity. When they were only half filled, the cost for storage in metal buildings and steel bins was about 50 percent higher than when fully utilized. For wood structures, it was 78 percent higher per bushel.

Figure 15 shows the relationship for farm structures between the fraction of total capacity which is not used for corn storage and added storage cost per bushel of corn stored. In all three types of structures, the added annual cost per bushel is highest in the smallest structures.

In all cases the right half of the curve is steeper than the left half, indicating that added annual cost per bushel increases more than proportionately as the percentage of total unused capacity increases. In general, the curves for the wood cribs are the steepest and the curves for the round steel bins are the flattest. This indicates that maintaining unused storage capacity is relatively most expensive in wood cribs, and least expensive in bins for shelled corn. For all 3 types of structures, the average cost per bushel stored was 3.12 cents more at 75 percent utilization and 9.39 cents more at 50 percent utilization than at full utilization.

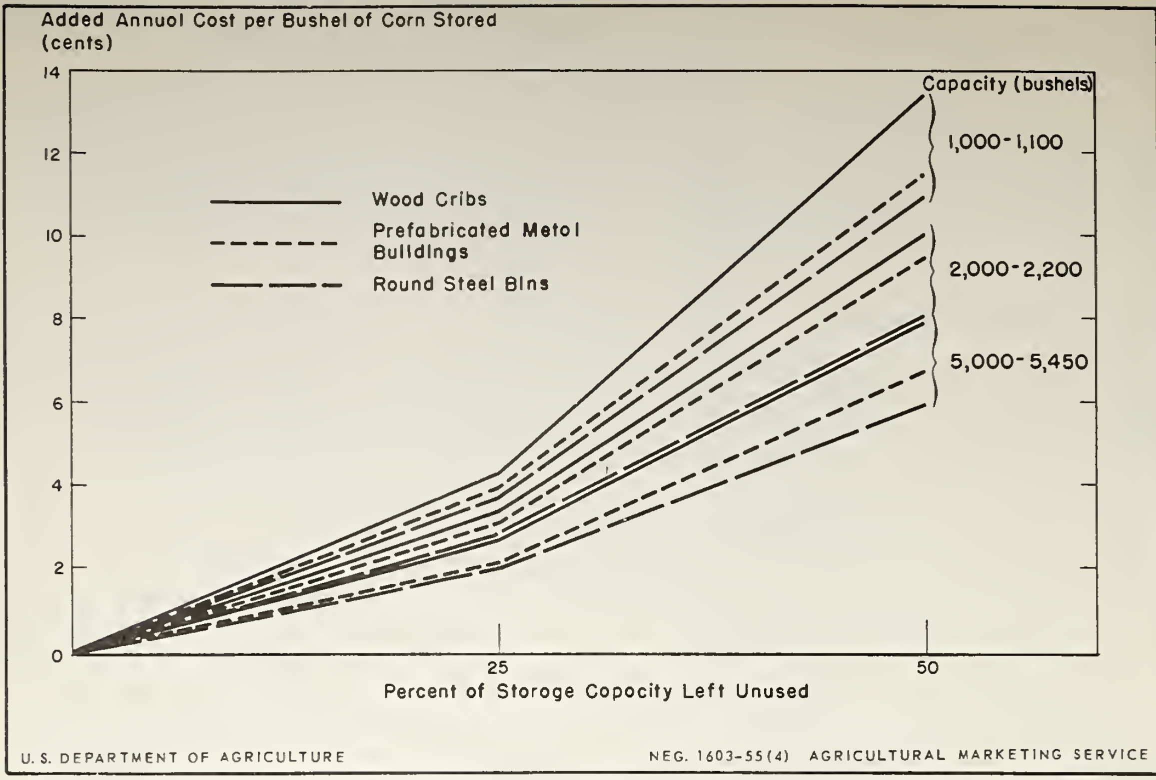

Figure 15.--Relationship between percentage of capacity unused and added annual cost per bushel of corn stored in farm structures.

Comparison of Individual Cost Items in Medium-Size Bins

Table 28 shows a comparison of cost items for medium-size bins of the three types used at full capacity.[26] Fixed costs make up 25 percent of the total costs for the round steel bins, compared with 58 percent and 70 percent of the total costs for the 2 types of ear-corn structures. In each instance, the influence of the original price of the structure and equipment is reflected in the items for depreciation and interest on investment, which are the two most important fixed costs.

Total variable costs for shelled-corn structures are double those for ear-corn bins. The most important variable for each type bin is the labor cost. In the case of round steel bins, it accounts for half the total costs of storage because of the amount of labor involved in filling and fumigating the bins. The cost of materials used for fumigation and rodent control is also much greater for shelled corn. This item accounts for 11 percent of total costs for the steel bins, compared with 2 and 3 percent for ear-corn structures. Extra handling also increases the amount chargeable to total variable costs in the case of shelled-corn storage.

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[26] The proportions are very similar for bins of the other 2 capacities and rates of utilization.

TABLE 28.--Fixed and variable costs, in dollars and as percentage of total cost, for 3 types of farm bins, utilized at 100 percent of capacity, based on 1952 local market prices

Cost items	Ear-corn structures[1]				Shelled-corn structures	
	Double wood crib 2,000 bushels		Prefabricated metal 2,200 bushels		Round steel bin 2,200 bushels	
	Dollars	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*
Original costs:						
Building (inc. materials and erection)	1,972.09	--	2,273.00	--	712.00	--
Equipment.......	0	--	524.00	--	58.50	--
Total.......	1,972.09	--	2,797.00	--	770.50	--
Fixed costs:						
Depreciation:						
Building......	53.24	20.0	113.65	26.3	35.60	10.8
Equipment.....	0	--	52.40	12.2	5.85	1.8
Interest........	80.76	30.3	114.94	26.6	32.31	9.9
Insurance.......	6.90	2.6	9.80	2.3	2.70	0.8
Property tax....	13.50	5.1	13.61	3.2	7.43	2.3
Total.......	154.40	58.0	304.40	70.6	83.89	25.6
Variable costs:						
Labor...........	78.00	29.2	81.90	19.0	163.80	50.0
Fumigation and rodent control	8.50	3.2	8.90	2.1	37.40	11.4
Insurance and tax on stocks.	11.00	4.1	12.12	2.8	12.12	3.7
Repairs.........	14.68	5.5	18.26	4.2	5.14	1.6
Electricity.....	0	--	5.77	1.3	3.38	1.0
Handling........	0	--	0	--	22.00	6.7
Total.......	112.18	42.0	126.95	29.4	243.84	74.4
Total costs.......	266.58	100.0	431.35	100.0	327.73	100.0
Cost per bushel year............	*Cents* 13.3		*Cents* 19.6		*Cents* 14.9	

[1] Capacities of ear-corn structures are indicated on shelled-corn basis.

Application of Budgeted Farm Storage Costs

When using the farm storage costs obtained in this study, it is essential that the conditions used for determining these costs be kept in mind. In any farm storage situation where these conditions do not apply, the farm storage costs reported in table 24 will not be accurate. In brief, costs cover the storage of corn on the farm the second year. Because of the way interest on investment was figured, the costs reported apply to the 3 types of structures after they have been put up new and used for 3 years. Costs in newer structures would be slightly higher and in older structures would be slightly lower than those reported.

It is also important to realize that the farm storage costs obtained in this study include certain cost items which farmers themselves often do not consider. The two most important of these are interest on investment and labor used to check on the stored corn from time to time. If these two items were left out of total farm storage costs, the per bushel storage costs would be substantially lower, as indicated in table 29.

TABLE 29.--Annual storage costs per bushel in farm structures excluding interest and labor charges

Utilization of capacity	Annual storage costs per bushel								
	Ear-corn structures[1]						Shelled-corn structures		
	Double wood crib			Prefabricated metal building			Round steel bin		
	1,000 bu.	2,000 bu.	5,000 bu.	1,100 bu.	2,200 bu.	5,000 bu.	1,000 bu.	2,200 bu.	5,450 bu.
Percent	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
100 percent......	6.9	5.4	4.7	11.2	10.6	7.9	6.9	5.9	5.3
75 percent......	8.6	6.8	5.8	12.9	12.3	9.1	8.2	7.0	6.2
50 percent......	12.3	9.5	8.3	16.4	15.7	11.6	10.7	9.0	8.1

[1] Capacities of ear-corn structures are indicated on shelled-corn basis.

By comparing this table with table 24, one can see that interest on investment and labor--the two major cost items which usually are not completely a paid-out expense to the farmer--make up over half of the total annual storage cost per bushel in wood cribs and steel bins, and nearly half of it in the prefabricated metal structures for ear corn. These two items are more important in farm storage costs than in elevator and bin site storage costs because of the relatively small size of individual farm storage operations.

It should be remembered also that the farm storage costs reported in this study were calculated to apply to "resealed" corn on farms, as opposed to storage at bin sites and elevators. Therefore, they cannot be used in estimating storage costs on farms for any purpose other than that for which they were designed. The farmer considering the cost of storage for resealing on his farm will find the costs in table 29 more useful than those reported in table 24. If he does not borrow money to put up his storage structure and does not hire labor to supervise the stored corn, the costs in table 29 are applicable. If he does have annual interest to pay and hires outside labor in connection with his storage, then he would need to adjust the figures in table 29 upward accordingly.

APPENDIX: STATISTICAL ANALYSIS

To provide the basis for the storage cost estimates at bin sites and in country elevators which are reported in the text, multiple regression equations were fitted to the cost and volume data obtained from the sample of 10 county bin site operations and 44 country elevators.

Model

The regression equations were computed in terms of total annual storage cost rather than per unit storage cost. The total cost model facilitated the computational procedure because the form of the equation was less complex than that for a satisfactory average cost model.[27] However, a statistically significant coefficient of determination may not have the same economic significance when the regression function is stated in terms of total cost as when stated in terms of average cost. The R^2 ordinarily should be higher when the function is stated in terms of total cost than when an average cost function is fitted to the same data. This is true because so long as any costs are variable, there will be some relationship between volume and total cost, even though there may be little or no relationship between volume and average cost.

Total annual storage cost at both bin sites and country elevators was set up as a function of four independent variables: (1) Average storage inventory for the year, (2) average unused storage capacity for the year, (3) volume of grain put into storage during the year, and (4) volume of grain taken out of storage during the year. Each of these four variables can and does vary independently in any given storage operation, and each variable can be expected to exercise a separate and distinct effect upon the total annual storage cost. A substantial range for each of these independent variables was observed in both the elevator and the bin site sample (see table 5 and table 19).

The model selected was:

(1) $Y = B_1 X_1^{.8} + B_2 X_2 + B_3 X_3 + B_4 X_4$, where
Y = total annual cost of storage
X_1 = average monthly bushel inventory of grain stored for the year[28]
X_2 = average unused storage capacity for the year in bushels
X_3 = bushels put into storage during the year
X_4 = bushels taken out of storage during the year

The four independent variables were ordered as indicated above on the basis of economic logic according to the relative magnitude of the effect they could be expected to exercise on total annual storage cost.

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[27] Not only did this model provide an equation which is linear with respect to three of the independent variables, but it also avoided other difficulties. Because the average cost curve is steep at small storage outputs, levels off sharply, and is virtually flat over the upper range, finding a suitable equation in terms of averages offers some trouble. An inverted equation of the type $Y = F(\frac{1}{X})$ is apparently required, which means that the intercept is specified at infinity on the X-axis rather than at some finite position on the Y-axis. In addition, an average cost function to fit the data would be somewhat complicated of the type

$$Y_a = A_1 + B_1 \left(\frac{1}{C_1 + X_1}\right) + \dots + A_n + B_n\left(\frac{1}{C_n + X_n}\right)$$

An equation of this type offers considerable difficulty in solution because of the number of unknown quantities involved. These problems were avoided by computing the regression equations in terms of total cost rather than per bushel cost.

[28] So that for any elevator or bin site the total storage capacity is the sum of X_1 and X_2.

The exclusion of a B_0 and the selection of the .8 exponent on X_1 in this model are based primarily on theoretical economic considerations. When the more familiar model, $Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4$, was fitted to the data by the method of least squares, the solution resulted in a negative B_0 because of the influence of the observations at the lower volume ranges of X_1. This linear equation was somewhat less satisfactory in providing a fit to the data than equation (1), but more important, the economic objections to such an equation are substantial. The average cost function associated with a linear total cost function with a negative B_0 is most unusual and unreasonable in nature, because it is an increasing function with volume throughout the lower volume range. This would lead one to the unrealistic conclusion that at least over some volume range cost efficiency is maximized by minimizing plant size and by minimizing operating volume for any given plant size.

It is much more reasonable to expect that total cost will be zero rather than negative (or positive) when all four of the above measures of grain storage are at zero. This conclusion was strongly supported by the observations at the lower volume range for both the elevator and bin site sample. But the selection of a linear total cost model which passes through the origin would also be economically unrealistic. Such a model would mean an average cost function which is constant over the entire volume range, support for which is borne out neither by economic logic nor the observed elevator and bin site cost data.

In order to correspond to an average cost function which decreases with volume at a decreasing rate, a 4-variable total cost function passing through the origin requires an exponent of less than 1 on 1 or more of the 4 variables. In this case the Bean method[29] revealed a slightly curvilinear relationship between average bushel inventory and total storage cost. The nature of this curvilinearity, i.e., the exponent on X_1 was determined to the nearest tenth by successive approximations from short cut computational procedure to find the smallest deviation sum of squares.

Using equation (1) as the model, the B parameters in the several multiple regression equations were estimated by the method of least squares from the elevator and bin site cost and volume data obtained from the samples selected (tables 5 and 19).[30]

Regression Analysis of the Country Elevator Data

The regression equation for the 44 country elevators, as determined from the data in table 5, is:

(2) $\hat{Y} = .165X_1^{.8} + .062X_2 + .022X_3 + .035X_4$ [31]

The coefficient of determination (R^2) was .988 for multiple regression equation (2). This means that about 99 percent of the variation in total storage cost is associated with variation in the 4 independent variables.

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[29] Bean, L. H. A Simplified Method of Graphic Curvilinear Correlation. Journal of the American Statistical Association. Vol. XXIV, pp. 386-397. Dec. 1929.

[30] These coefficients were estimated by solving the following set of equations:

$$\Sigma[X_1 Y] = b_1 \Sigma(X_1^{.8})^2 + b_2\Sigma(X_1^{.8}X_2) + b_3\Sigma(X_1^{.8}X_3) + b_4\Sigma(X_1^{.8}X_4)$$

$$\Sigma(X_2 Y) = b_1\Sigma(X_1^{.8}X_2) + b_2\Sigma(X_2)^2 + b_3\Sigma(X_2X_3) + b_4\Sigma(X_2X_4)$$

$$\Sigma(X_3 Y) = b_1\Sigma(X_1^{.8}X_3) + b_2\Sigma(X_2X_3) + b_3\Sigma(X_3)^2 + b_4\Sigma(X_3X_4)$$

$$\Sigma(X_4 Y) = b_1\Sigma(X_1^{.8}X_4) + b_2\Sigma(X_2X_4) + b_3\Sigma(X_3X_4) + b_4\Sigma(X_4)^2$$

[31] Equation (2) as well as the equations which follow [(3), (4), (5), (6), (7), (8)] is based on the usual assumptions of additive effects of the variables, normal and independent distribution of the error (unexplained residual) and equal variance of the dependent variable at all values of the independent variables.

The standard errors for the partial regression coefficients[32] in equation (2) are as follows:

$b_1 = .165^{**}$ $\qquad s_{b_1} = .005$
$b_2 = .062^{**}$ $\qquad s_{b_2} = .009$
$b_3 = .022$ $\qquad s_{b_3} = .011$
$b_4 = .035^{**}$ $\qquad s_{b_4} = .008$

** Significant at the 1 percent level.

The simple correlation coef icients (r's) for the variables in equation (2) are shown in table 30.

TABLE 30.—Simple correlation coefficients (r's) among variables in equation (2) for country elevators (based on data in table 5)

Item	Average monthly inventory[1]	Unused capacity	Bushels put in	Bushels taken out	Total storage cost
Average monthly inventory....	1	-.015	-.116	.467	.939
Unused capacity............	....	1	.348	.135	.245
Bushels put in............	....	....	1	.128	.067
Bushels taken out..........	....	....	....	1	.591
Total storage cost..........	....	....	....	....	1

[1] Because the regression function is $Y = f(X_1^{.8}, X_2, X_3, X_4)$, the simple correlation coefficients are actually related to average monthly inventory to the eight-tenths power. It is to be noted that these correlation coefficients do not enter into the solution of the normal equations given in footnote 30, p. 52.

If two independent variables are correlated perfectly ($r = 1$), then the use of both in the analysis is unnecessary. Since none of the r's in the above table indicate a high decree of intercorrelation among independent variables, no statistical test was used to determine whether or not a satisfactory regression equation could be obtained omitting one of these variables. There is considerable economic logic for retaining all four of the independent variables.

Multiple regression equations were also determined from the data in table 5 for each type of elevator storage structure as follows:

For the concrete elevators:

$$(3)\ \hat{Y} = .171\ X_1^{.8} + .063\ X_2 + .017\ X_3 + .029\ X_4$$

For the wood elevators:

$$(4)\ \hat{Y} = .163\ X_1^{.8} + .074\ X_2 + .034\ X_3 + .024\ X_4$$

[32] The partial regression coefficients have been rounded to 3 places for the purpose of simplifying the equation. The original computations were: $b_1 = .165,163$, $b_2 = .062,149$, $b_3 = .0218,168$, $b_4 = .034,634$

For the steel tank elevators:

(5) $\hat{Y} = .156\, X_1^{.8} + .036\, X_2 + .040\, X_3$[33]

For the flat steel storage facilities:

(6) $\hat{Y} = .135\, X_1^{.8} + .002\, X_2$[34]

The multiple coefficients of determination (R^2) were determined for each of these regression equations. The R^2 values were:

	R^2
Concrete elevators (equation (3))	.992
Wood elevators (equation (4))	.990
Steel tank elevators (equation (5))	.988
Flat steel elevators (equation (6))	.971

The next step in the statistical analysis was to test the homogeneity of the regression equations for the four types of elevators. This test is shown in table 31.

Since the added reduction in mean squares due to separate regression is smaller than the mean squares deviation from the individual regressions, one overall regression function was used to predict total storage cost in all types of elevators.

TABLE 31.--Analysis of variance of the regression of total storage cost on X_1, X_2, X_3, and X_4 for country elevators in terms of overall regression and individual regressions by types of storage structure

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Total	44	5020.2169	—
Reduction due to one overall regression	4	4958.568	—
Deviation	40	61.6489	—
Reduction due to separate regressions	16	4975.9521	—
Deviations for individual regressions	28	44.2648	1.581
Added reduction due to separate regressions	12	17.3841	1.158

[33] Because only one elevator of this group moved grain out of storage, there was not enough information for estimating the regression coefficient for the fourth variable. The estimates of the coefficients of X_1, X_2, and X_3 should not be interpreted directly as estimates of the coefficients of the same variables had information for X_4 been available. However, in view of the fact that the data on X_4 is not available, the above estimates are presented as the best at hand. This will not invalidate the test of homogeneity between the different types of elevator structures because in the computations of the pooled regression, zero values of X_4 were used for all observations exhibiting no volume of this variable. This procedure was also used in the case of X_2 and X_4.

[34] The sample did not furnish enough information to estimate the regression coefficients for the third or fourth variables. See footnote 33.

Estimation of Storage Costs in Country Elevators From the Regression Equation

The estimated storage costs in country elevators reported in figures 3-7 and tables 10-12 were determined from regression equation (2) by substituting in the appropriate values for each of the four independent variables. This procedure does not go beyond the actual range for each variable observed in the sample. However, it makes the assumption that elevators at particular volume ranges for each variable exhibit the same regression pattern as the entire sample of 44 elevators.

The curve in figure 3 was computed by setting X_2, X_3, and X_4 in equation (2) equal to zero, and then solving for a series of total costs associated with a given series of values for average monthly inventory, X_1. The curve in figure 4 was computed by dividing each so-computed total storage cost by the corresponding average monthly inventory.

The points dispersed around the curve in figure 3 were located by subtracting from the observed total cost for each elevator any costs computed from regression equation (2) to be due to the observed values of X_2, X_3, and X_4 for that elevator and plotting the resultant cost against the observed average monthly inventory for the elevator. For example, this computation for elevator number 7 (see table 5) was:

Computed full-capacity, no-turnover, storage cost =
\$12,640 - (.062)(8,490) - (.022) (14,140) - (.035) (82,890) = \$8,901.

This computed storage cost of \$8,901 was plotted against the average monthly inventory of 165,510 bushels for elevator number 7.

The derived net relationship between storage cost in country elevators and storage capacity as shown in figure 5 and table 10, was computed from regression equation (2). In this case the values for X_1, X_2, X_3, and X_4 were related to storage capacity, X_c, which is the sum of X_1 and X_2. The average storage period considered is 2 years, so that at all capacities and degrees of utilization considered, the values of both X_3 and X_4 equal one-half that of X_1. At 50 percent capacity utilization, $X_2 = .5X_c$, at 75 percent capacity utilization $X_2 = .25X_c$, and at 100 percent capacity utilization $X_2 = 0$. Where D is the degree of capacity utilization in percent of capacity and X_c is total storage capacity, $X_1 = X_cD$, so that the equation used was

$$\hat{Y} = .165\,(X_cD)^{.8} + .062\,[(1.00-D)X_c] + .022\left(\frac{X_cD}{2}\right) + .035\left(\frac{X_cD}{2}\right)^{35}$$

The per bushel costs shown in figure 5 and table 10 were determined by dividing the total costs so computed by X_1. The per bushel storage cost of 14.08 cents shown in the first line of the third column in table 10 was computed as follows:

$$14.08 = \frac{.165\,[(.75)(25)]^{.8} + .062\,[(.25)(25)] + .022\left[\frac{(.75)(25)}{2}\right] + .035\left[\frac{(.75)(25)}{2}\right]}{(.75)(25)}$$

The derived net relationship between storage costs and the degree of utilization of storage capacity in country elevators as shown in figure 6 and table 11 was also computed from regression equation (2). In this case the values for X_1, X_2, X_3, and X_4 were related to storage capacity, X_c, which is equal to the sum of X_1 and X_2. Again the average storage period considered is 2 years, so that at all capacities and degrees of utilization considered the values of both X_3 and X_4 equal to half that of X_1. Where D is the degree of capacity utilization in percent of capacity and X_c is total storage capacity, the equation used was:

$$\hat{Y} = .165\,(X_cD)^{.8} + .062\,X_c\,(1.00-D) + .022\left(\frac{X_cD}{2}\right) + .035\left(\frac{X_cD}{2}\right)^{35}$$

[35] Because the cost and volume data in table 5 were coded in \$1,000 and 1,000 bushels in the computation of regression equation (2), X_c in this equation is capacity in 1,000 bushels and Y is total storage cost in \$1,000.

The per bushel storage costs were obtained by dividing the resultant Y by average monthly inventory, which in this case is $X_C D$. Thus, the per bushel cost figure of 14.25 cents shown in the next to last line of the third column in table 11 was computed as follows:

$$14.25 = \frac{.165\,[(100)(.6)]^{.8} + .062\,[(100)(.4)] + .022\left[\frac{(100)(.6)}{2}\right] + .035\left[\frac{(100)(.6)}{2}\right]}{(100)(.6)}$$

Regression equation (2) was also used to compute the derived net relationship between storage costs and the average length of storage in country elevators shown in figure 7 and table 12. Here the degree of capacity utilization considered is 90 percent, so that for all capacities (X_C) and all average lengths of storage considered, $X_1 = .9X_C$ and $X_2 = .1X_C$. Where T is the average length of storage in years, the equation used was $\hat{Y} = .165(.9X_C)^{.8} + .062(.1X_C) + .022\left(\frac{.9X_C}{T}\right) + .035\left(\frac{.9X_C}{T}\right)$.[36] The estimated storage costs per bushel shown in figure 7 and table 12 were obtained by dividing the resultant Y by average monthly inventory, $.9X_C$. Thus, the per bushel storage cost of 8.42 cents shown in the sixth line of the fourth column in table 12 was computed as follows:

$$8.42 = \frac{.165\,[(200)(.9)]^{.8} + .062\,[(200)(.1)] + .022\left[\frac{(200)(.9)}{3}\right] + .035\left[\frac{(200)(.9)}{3}\right]}{(200)(.9)}$$

Regression Analysis of the Bin Site Data

The regression equation for the unadjusted bin site storage costs as determined from the data in table 19 is:

(7) $\hat{Y} = .577\,X_1^{.8} + .016\,X_2 + .076\,X_3 + .015\,X_4$[37]

The coefficient of determination (R^2) was .99, and hence about 99 percent of the variation in total storage cost is associated with variation in the 4 independent variables. Since there are only 6 degrees of freedom for error, the significance of the reduction in sum of squares due to regression equation (7) was tested. The result was $F_{4,6} = 115.76$ which is significant at the 1 percent level.

The standard errors for the partial regression coefficients[38] in equation (7) are as follows:

$b_1 = .577^{**}$	$s_{b_1} = .125$
$b_2 = .016$	$s_{b_2} = .013$
$b_3 = .076$	$s_{b_3} = .035$
$b_4 = .015$	$s_{b_4} = .022$

** Significant at the 1 percent level.

The bin site storage costs were adjusted to make them comparable with the elevator storage costs (see p. 26). Since this adjustment was not constant for all ten sample counties, a separate regression equation was fitted to the adjusted storage costs.

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[36] X_C and $\hat{Y}$ in 1000's. See preceding footnote.

[37] This model is discussed in the first section of the appendix.

[38] The partial regression coefficients have been rounded to 3 places for the purpose of simplifying the equation. The original computations were: $b_1 = .577,193$, $b_2 = .016,095$, $b_3 = .076,280$, $b_4 = .015,287$

The regression equation for the adjusted bin site storage costs as determined from the data in table 19 is

(8) $\hat{Y} = .755 X_1^{.8} + .021 X_2 + .085 X_3 + .011 X_4$

The coefficient of determination (R^2) was .99 for the adjusted bin site storage cost equation, so that about 99 percent of the variation in total storage cost is associated with variation in the 4 independent variables. The significance of the reduction in sum of squares due to regression equation (8) was tested with the result, $F_{4,6} = 141.4$, which is significant at the 1-percent level.

The standard errors for the partial regression coefficients[39] in equation (8) are as follows:

$b_1 = .755$**	$s_{b_1} = .139$
$b_2 = .021$	$s_{b_2} = .014$
$b_3 = .085$	$s_{b_3} = .038$
$b_4 = .011$	$s_{b_4} = .025$

** Significant at the one percent level.

The simple correlation coefficients (r's) for the variables in equation (8) are shown in table 32. (For explanation of this table, see table 30, appendix, p. 53.)

TABLE 32.--Simple correlation coefficients (r's) among the variables in equation (8) for the adjusted bin site costs (based on data in table 19)

Item	Average monthly inventory	Unused capacity	Bushels put in	Bushels taken out	Total storage cost
Average monthly inventory	1	.343	.845	.305	.954
Unused capacity		1	.320	.374	.423
Bushels put in			1	.367	.897
Bushels taken out				1	.421
Total storage cost					1

Estimation of Storage Costs at Bin Sites from the Regression Equations

The estimated storage costs at bin sites reported in figures 9-13 and tables 20-22 were determined from regression equations (7) and (8) in the same manner as the estimated storage costs in country elevators were determined from regression equation (2). (See appendix, p. 52). The solid and the broken curves in figure 9 were computed by setting X_2, X_3 and X_4 equal to zero in equation (7) and equation (8), respectively, and then solving for a series of total costs associated with a given series of values for average monthly inventory X_1. The curves in figure 10 were computed by dividing each so computed total storage cost by the corresponding average monthly inventory.

The points dispersed around the two curves in figure 9 were located in the same manner as those plotted around the curve in figure 3 (see appendix, p. 55). This computation for county number 6 (see table 19) in the case of the adjusted storage cost was:

Computed full-capacity, no-turnover storage cost =
$215,718 - (.021)(733,266) - (.085)(623,071) - (.011)(162,467) = $145,571

[39] The partial regression coefficients have been rounded to 3 places for the purpose of simplifying the equation. The original computations were: $b_1 = .754,861$, $b_2 = .020,589$, $b_3 = .085,252$, $b_4 = .010,765$

This computed adjusted storage cost of $145,571 was plotted against the average monthly inventory of 3,658,023 bushels for county number 6.

The derived net relationship between storage cost at bin sites and average monthly inventory shown in figure 11 and table 20 was computed from regression equations (7) and (8) in the same manner as the elevator costs in figure 5 and table 10 were derived from regression equation (2) (see appendix, p. 55). Where D is the degree of capacity utilization in percent of capacity and X_c is total storage capacity, $X_1 = X_cD$, so that the equation used for the unadjusted costs was

$$\hat{Y} = .577\,(X_cD)^{.8} + .016\,[(1.00-D)X_c] + .076\left(\frac{X_cD}{2}\right) + .015\left(\frac{X_cD}{2}\right)$$

while the equation used for the adjusted costs was:

$$\hat{Y} = .755\,(X_cD)^{.8} + .021\,[(1.00-D)X_c] + .085\left(\frac{X_cD}{2}\right) + .011\left(\frac{X_cD}{2}\right)$$

The per bushel costs shown in figure 11 and table 20 were determined by dividing the total costs so computed by X_1. The per bushel storage cost of 9.39 cents shown in the fifth line of the fourth column of table 20 was computed as follows:

$$9.39 = \frac{.577\,[(.75)(600)]^{.8} + .016\,[(.25)(600)] + .076\left[\frac{(.75)(600)}{2}\right] + .015\left[\frac{(.75)(600)}{2}\right]}{(.75)(600)}$$

while the figure of 11.07 cents shown in the fifth line of the fifth column of table 20 was computed as follows:

$$11.07 = \frac{.755\,[(.75)(600)]^{.8} + .021\,[(.25)(600)] + .085\left[\frac{(.75)(600)}{2}\right] + .011\left[\frac{(.75)(600)}{2}\right]}{(.75)(600)}$$

The derived net relationship between storage costs and the degree of utilization of storage capacity at bin sites in figure 12 and table 21 was computed from regression equations (7) and (8) in the same manner as the elevator costs in figure 6 and table 11 were derived from regression equation (2) (see appendix, p. 55). Where X_c is total storage capacity and D is the degree of capacity utilization in percent of capacity, the equation used for the unadjusted costs was:

$$\hat{Y} = .577\,(X_cD)^{.8} + .016\,X_c\,(1.00-D) + .076\left(\frac{X_cD}{2}\right) + .015\left(\frac{X_cD}{2}\right)$$

while the equation used for the adjusted costs was

$$\hat{Y} = .755\,(X_cD)^{.8} + .021\,X_c\,(1.00-D) + .085\left(\frac{X_cD}{2}\right) + .011\left(\frac{X_cD}{2}\right)$$

The per bushel storage costs shown in figure 12 and table 21 were obtained by dividing the resultant $\hat{Y}$'s by the average monthly inventory, which in this case is X_cD. Thus, the per bushel storage cost of 8.96 cents shown in the third line of the fourth column of table 21 was computed as follows:

$$8.96 = \frac{.577\,[(800)(.80)]^{.8} + .016\,[(800)(.20)] + .076\left[\frac{(800)(.80)}{2}\right] + .015\left[\frac{(800)(.80)}{2}\right]}{(800)(.80)}$$

While the figure of 10.52 cents shown in the third line of the fifth column of table 21 was computed as follows:

$$10.52 = \frac{.755\,[(800)(.80)]^{.8} + .021\,[(800)(.20)] + .085\left[\frac{(800)(.80)}{2}\right] + .011\left[\frac{(800)(.80)}{2}\right]}{(800)(.80)}$$

Regression equations (7) and (8) were also used to compute the derived net relationship between storage costs and the average length of storage at bin sites shown in figure 13 and table 22, in the same manner as regression equation 2 was used to compute this relationship for country elevators in figure 7 and table 12 (see appendix, p. 56). Where T is the average length of storage in years and X_c is total capacity, the equation used for the unadjusted costs was $\hat{Y} = .577\ (.9X_c)^{.8} + .016\ (.1X_c) + .076 \left(\frac{.9X_c}{T}\right) + .015 \left(\frac{.9X_c}{T}\right)$ while the equation used for the adjusted costs was $\hat{Y} = .755\ (.9X_c)^{.8} + .021\ (1X_c) + .085 \left(\frac{.9X_c}{T}\right) + .011 \left(\frac{.9X_2}{T}\right)$. The estimated per bushel storage costs shown in figure 13 and table 22 were obtained by dividing the resultant $\hat{Y}$'s by average monthly inventory, $.9X_c$. The per bushel storage cost of 7.70 cents shown in the sixth line of the second column of table 22 was computed as follows:

$$7.70 = \frac{.577\ [(400)(.9)]^{.8} + .016\ [(400)(.1)] + .076 \left[\frac{(400)(.9)}{3}\right] + .015 \left[\frac{(400)(.9)}{3}\right]}{(400)(.9)}$$

While the figure of 9.27 cents shown in the sixth line of the third column of table 22 was computed as follows:

$$9.27 = \frac{.755\ [(400)(.9)]^{.8} + .021\ [(400)(.1)] + .085 \left[\frac{(400)(.9)}{3}\right] + .011 \left[\frac{(400)(.9)}{3}\right]}{(400)(.9)}$$

DEFINITIONS

Adjusted bin site storage cost. An adjusted cost figure obtained by computing costs for insurance and taxes and adding them to expenses incurred in the storage of corn at bin sites as reported in Government accounting records. Since Government agencies do not pay taxes or insurance, this adjustment was made so that costs of storage at bin sites and costs which would be borne by private enterprise engaged in the same type of storage would be comparable.

Annual storage cost per bushel. Cost of storing 1 bushel of corn for 1 year.

Average length of storage. This is a measure of the relationship between the volumes of corn moved into and out of storage during the year and the average monthly inventory of stored grain. It is computed from the rate of turnover of storage inventory. If the average turnover is 100 percent, the average length of storage is 1 year, because the bushels put into and taken out of storage equal the bushels stored. If the annual turnover is only 20 percent of the grain stored, the average length of storage is 5 years.

Average monthly inventory. A measure of storage volume computed by adding the monthly inventory figures for 12 months (obtained from accounting records) and dividing the resulting sum by 12. This figure gives the average number of bushels of corn stored each month for a period of one year.

Bin site. A group of steel or wood storage bins placed on sites located in areas of surplus-grain production. As used in this study, bin sites refer to groups of such bins which are the property of the Federal Government.

Degree of utilization. Degree of utilization is another way of measuring unused storage capacity. It is more meaningful than total unused capacity when discussing per bushel rather than total storage costs. At 100 percent utilization, unused capacity is zero. At 75-percent utilization, unused capacity amounts to one-fourth of the storage capacity. At 50 percent utilization, unused capacity is equal to one-half the total capacity.

Licensed capacity. Number of bushels of bulk grain storage for which an elevator is licensed by either State or Federal agencies.

Storage capacity. Volume of space, measured in bushels of grain, which is suitable for storage purposes.

Unused storage capacity. Volume of space which is suitable for storage purposes but is not utilized as such. The figure, in bushels, is obtained by subtracting the average monthly inventory from the storage capacity figure.

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